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HEATING BY STEAM AND WATER

A PRACTICAL TREATISE ON

HOUSE HEATING

Improved Methods of Installing Heating Apparatus in the Home. Short and
accurate Rules for Computing Radiation, Heat Losses, etc. Graphic
Charts showing Boiler Power and Coal Consumption. Accurate
data, consisting of Charts, Illustrations and Description of how
best to Heat Water for Baths, Swimming Pools, etc., etc.

Specially written and compiled for THE PLUMBERS' TRADE JOURNAL

BY CHAS. B. THOMPSON

Two Hundred and Sixty-eight Original Drawings

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INTRODUCTORY

The greater part of the material in the following pages is compiled from a series of articles written for the PLUMBERS' TRADE JOURNAL, entitled "Hints on House Heating." The text has, however, been revised, some new material has been added, and the book is now offered to the trade with the hope that it may prove especially helpful to those who are chiefly interested in House Heating Apparatus.

In the first part of the book are illustrated and described, a number of examples of Steam and Water Heating Apparatus, which have been in actual operation for ten or fifteen years, and which may be considered as fair examples of good, average current practice.

The greater portion of the work described was installed under the writer's supervision, and compares favorably with the better class of house heating apparatus.

The writer, however, believes that in the near future, new methods of house heating will be evolved that will be a large improvement over present practice.

For example: Steam will displace water as a residence heating medium, when it can be installed so the heat in each unit of radiation is under perfect control, and so that the various radiators may be run at any desired temperature, without changing the initial temperature at the boiler, excelling in this feature the best installation of water heating apparatus extant.

In the latter part of the book numerous examples of steam and water heating are shown, which some heating men may classify as "freaks," inasmuch as the pipe sizes employed are much smaller than those commonly used by the trade.

Nothing is shown, however, that has not been tried in practice, and it is the firm conviction of the writer that still smaller pipes than are mentioned in any part of this work will come into general use with increased knowledge of the science of Steam and Water Circulation at High Velocities.

Turn to the diagram on page 260 representing the relative volume of Steam and Water, and on page 186 note the space occupied by the condensation from a given quantity of condensing surface, and then think of a rational excuse for using a 3-inch return for a 5-inch supply, as is quite often done, or in two-pipe work, for the use of a 1½-inch supply and a 1¼-inch return, for 100 square feet of radiation.

Those who believe that current practice in the way of pipe sizes cannot be improved upon, may find something of interest in the first 40 chapters, while those who believe in progression, will find many helpful hints in the last 90 pages.

In the article on "Heat Transmission," pages 15 to 25, the various data for determining quantities have been resolved into simple factors, which will facilitate the work of computation, and a table of multiplying decimals has been provided for increasing or diminishing the radiation, according to prevailing local conditions.

The article on Velocities of Steam in Pipes will be found very helpful to those who are not familiar with the subject, and the suggestion in regard to the priming of boilers and the intelligent use of small piping, is worth many times the price asked for this book.

C. B. T.

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HEATING BY STEAM AND WATER

CHAPTER I.

THE FIRST IMPORTANT FACTOR TO CONSIDER IN PROPERLY PROPORTIONING A HEATING APPARATUS.

THE art of house heating is not as yet an exact science, but in the past few years rapid strides have been made toward formulating laws for all the different phenomena of heat. The practical application of these laws will go far towards placing the house-heating business on a scientific and solid basis.

The literature on the subject has usually been written by men of high scientific attainments, and much of the important data has been reduced to algebraic formula, which is unintelligible to the great body of workers in this particular field of industry.

In these papers it is the writer's purpose to use only such terms and phrases as will be readily understood by men of average education.

The measure of heat used in this country is the British thermal unit, which is the quantity of heat necessary to raise the temperature of one pound of water one degree Fahrenheit.

This heat unit will be used in this book for the sake of illustration, because it is impossible to write or talk intelligently or correctly on the subject of heating without using some unit of measurement.

For example, a pound of anthracite coal in burning to dioxide, or perfect combustion, will yield about 13,000 heat units B. T. U.

The water in the boiler absorbs a certain percentage of the heat yielded by the coal, and this heat is available to warm the piping and radiation attached to the boiler. The piping and radiation lose their heat to the surrounding air, which in turn is cooled by the glass, outside walls, and by mixing with the colder air which comes into the room by the various openings about the windows, etc. The air which enters must of course escape by some exit, which is usually an open fireplace. To the fresh air which thus enters the rooms, we are indebted for the measure of ventilation we enjoy during the season of artificial heat, except, of course, in the rare instances where ventilation is specifically provided.

This book treats of low pressure steam and water heating only, leaving the hot air system to those who are better qualified to give instructions regarding its installation.

RADIATION.

To determine how much radiation is necessary to heat a given space it is well to remember that a room loses its heat; 1st, through the glass; 2d, through the outside walls; and 3d, through the fresh air entering the room.

The loss of heat is in proportion to the difference between the temperature of the air in the room, and the external temperature. It is usual to call the inside temperature 70 degrees, the external 0 degrees, and say the difference is 70 degrees, proportioning the radiation to maintain a temperature of 70 degrees in the rooms in zero weather.

An apparatus so proportioned in all its parts will, as a rule, maintain the 70-degree temperature as easily at 20 degrees below zero as it will at zero, for the reason that in the extremely low temperatures there is rarely any wind, while at zero and 10 above the cold wave is frequently accompanied by high winds which drives the heat out of the building more rapidly than will any other agency.

To use the cubic contents of a room as a basis for obtaining the proper amount of radiation is misleading, as the radiation so computed will overheat one room and underheat another.

A rule that is used by a number of steam heating contractors for computing the quantity of radiation necessary to warm rooms by low pressure steam heating apparatus, is as follows:

1 square foot radiation to 2 square feet of exposed glass;

1 square foot radiation to 20 square feet of exposed wall;

1 square foot radiation to 200 cubic feet of air.

In Fig. 1 is shown the first floor of a small residence. Each room contains the same cubic feet of air, but the cooling surface differs in each.

Figuring by cubic contents and apportioning 1 square foot of radiation to 45 cubic feet of air, we would have exactly 50 square feet in each room, or a total of 200 square feet, while the above rule gives 188 square feet. A comparison of results obtained by the two methods will be instructive and noteworthy as follows:

	Cubic Contents. Ratio 1:45	Above Rule. Ratio 2—20—200
Room A ...	50	52
Room B ...	50	45
Room C ...	50	29
Room D ...	50	62
	200	188

While the 2-20-200 rule can be relied upon to give good average results, where the proportion of exposed wall and glass does not greatly vary some attention must be given to the coldest quarter and the most distant radiator from the boiler. Where the prevailing winter winds are from the northwest it is well to add 20 per cent to the radiation in the northwest room and deduct 20 per cent. from the more favored rooms, such as the southern exposure. Now as this radiation is for steam, with a mean or average temperature in the radiation of 220 degrees, what percentages shall we add for water?

In the ordinary house job of water heating where the circulation is free, the water should return to the boiler with a loss of from 15 to 20 degrees in temperature. If the water leaves the boiler at 180 degrees and returns at 160, then the mean or average temperature of the radiation will be 170 degrees. Assume a high efficiency for the radiation, placing it at 2 heat units loss per square foot per hour per degree of difference, and we have in the steam job—temperature of radiation, 220 degrees; temperature of room, 70 degrees; temperature difference, 150 degrees; loss or emission 2 heat units per square foot per degree of difference equal 300 heat units loss per hour per square foot of radiation.

In the water radiator at 170 degrees average temperature the loss will be 200 heat units figured by the same rule, so there will be required just 50 per cent. more radiation for water than for steam.

If the water radiators are 160 as against steam at 220, we must add 66 2-3 per cent. If 150, the difference will be 87 1-2 per cent., and if 145 degrees, as against 220 degrees, the surface will have to be doubled to get the same results.

If on the other hand the water radiation can be held at a mean temperature of 200 degrees as against 220 degrees in the steam, only 15½ per cent. need be added.

It is good practice, however, in water heating to figure for a temperature in the radiators of 165 to 170 for coldest winter weather and to add 60 per cent. to the radiation derived from the steam rule. This gives the following figures:

	Water Radiation.
Room A	83 sq. ft.
Room B	72 " "
Room C	47 " "
Room D	99 " "
	301 " "

As it is usual to use a radiator for water heating containing 5 square feet to the loop, we will take the nearest multiple of 5 for the number of loops required, and as

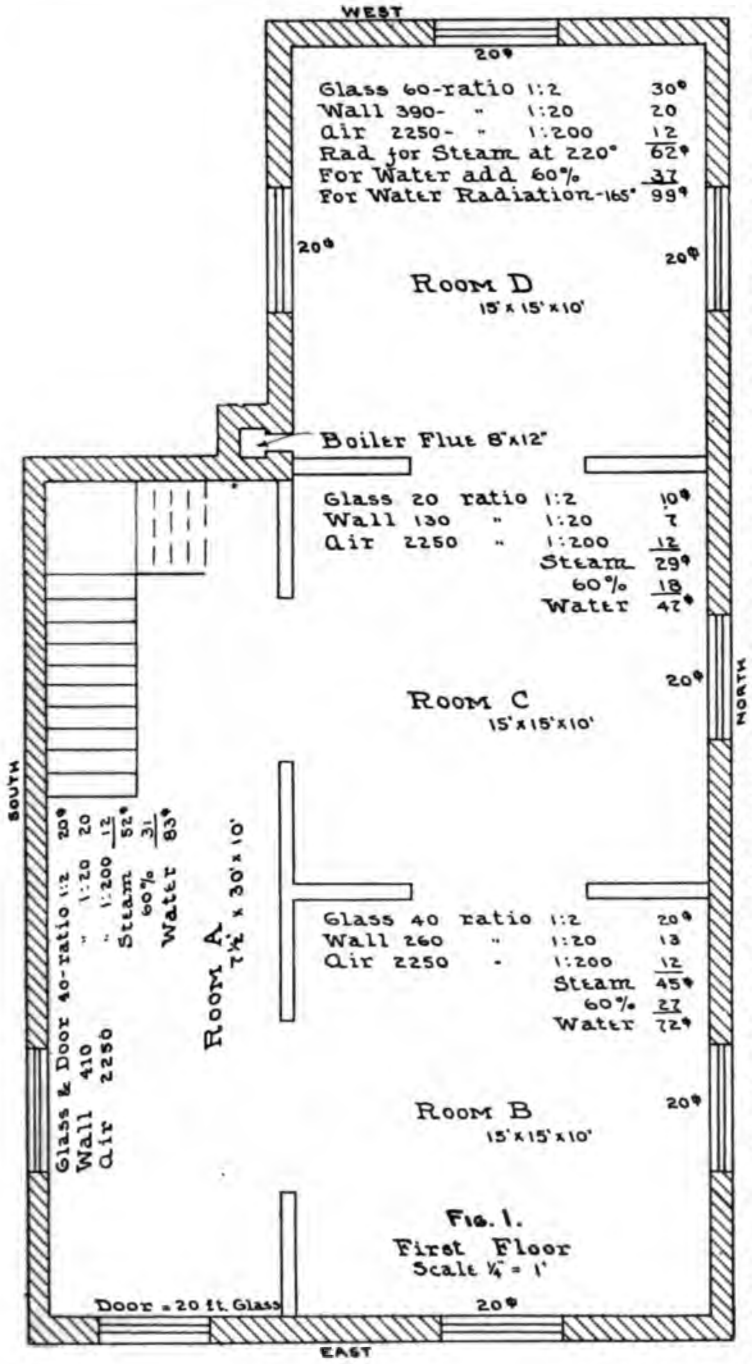


FIG. 1—SHOWING A, FIRST FLOOR PLAN OF A SMALL RESIDENCE, EACH ROOM CONTAINING SAME CUBIC FEET OF AIR, BUT COOLING SURFACES DIFFERENT IN EACH ROOM

the northwest room D is in the coldest quarter and the hall A on the warmest side we will distribute the radiation as follows for steam at 220 degrees, and water at 170 degrees in the radiators:

	Steam.	Water.
Room A	40	65
Room B	45	70
Room C	30	50
Room D	75	120
	190	305

We will assume there is a second floor to be warmed, which may be treated in the same manner as the first floor. It frequently happens that in the upper hall there is no room for a radiator, in which event the surface required for it may be added to the lower hall, this will, however, make a large and unsightly radiator, which can be avoided by heating the two halls by an indirect placed underneath the joists of the first floor hall. If this is done, there should be added to the direct radiation required 75 per cent. for indirect. Suppose the job is steam and the two halls require 75 square feet direct; adding 75 per cent. gives 132 square feet for the indirect, and as the water of condensation from the indirect will return to the boiler at a much lower temperature than will the water from the direct surface, because of the cold air passing over its surface, there must be provision made for boiler power to equal the increased load.

It is usual to allow for this increase in loss of temperature by counting the indirect 50 per cent. larger than its actual capacity.

In the case cited above in a steam job we would have:

Room B, direct	45
Room C, direct	30
Room D, direct	75
Room A, indirect	182
This gives a grand total of	282
Add for increased boiler power on account of indirect	66
3 radiators on second floor	150
	498
Add 20 per cent. for piping	100
	598

This gives the required boiler capacity, but as it is poor economy to put in a boiler that will *just do* the work, so is it good practice to add at least 25 per cent. to the radiation thus obtained and select a boiler of 750 to 800 feet rated capacity or thereabouts.

There are many cases where for a job of this size a boiler rated at 500 would be selected, but such work is always unsatisfactory.

Many instances have come under the writer's observation where the boiler has been selected before the proper amount of radiation was determined, but it will be obvious from what has been written that the radiation which warms the rooms is the first important factor in properly proportioning a heating apparatus.

CHAPTER II.

HEAT TRANSMISSION AND ITS APPLICATION.

IT is assumed that the 2-20-200 rule referred to in chapter one, page 12, is based on the varying rates of heat transmission for different building material; that it contemplates a temperature difference of 70 degrees between internal and external; that is, the external air at zero and the rooms at 70 degrees; and that the air of the rooms shall change once per hour.

The rule has the merit of simplicity and of being easily remembered and for a certain set of cooling proportions, may be used to good advantage, but where the window or wall surface is of unusual proportions, or for other temperature differences, such as external zero, internal 50 degrees, or external 40 degrees, internal 70 degrees, or where there is more than one change of air per hour, it has no value.

The item "1 sq. ft. to 200 cu. ft. of air" provides for one change of air per hour, and assumes that one B. T. U. will raise the temperature of 50 cubic feet of air one degree. This is not exactly correct, but is close enough for practical purposes. (One B. T. U. will add one degree F. to 48.7 cubic feet of air at zero and to 56.3 cubic feet at 70 deg., making the average between zero and 70 deg. 52.5 cubic feet.) If the air enters the room at zero and is warmed to 70 degrees, the rule assumes that 70 units of heat are required to raise the temperature of 50 cubic feet of air from zero to 70 deg., and as there are four 50's in 200, we find by multiplying 70 by 4, that we obtain 280 B. T. U., which the rule assumes is emitted by one square foot of radiation per hour.

The rule for walls (1 to 20) is probably based on a 12-inch wall with a temperature difference of 70 deg., and if so, the proportion of radiation is not enough. This rule should read "1 : 12.5" instead of "1 : 20," because at 70 deg., temperature difference a 12-inch brick wall will lose 22.4 B. T. U. per square foot per hour, which multiplied by 12.5 gives 280 B. T. U., the amount of heat which the rule assumes is emitted by one square foot of radiation.

For the glass, 1 square foot of radiation to 2 square feet of glass assumes that one square foot of glass will lose 140 B. T. U. per hour with 70 deg. temperature difference, but by the law of cooling, one square foot of glass, under these conditions, will lose but 72 B. T. U. and 4 times 72 is 288, showing that one square foot of radiation will furnish almost as much heat as is lost by 4 *square feet of glass*. This is, of course, assuming that the windows are perfectly tight, and that a square foot of radiation will give off 280 B. T. U. per hour, but in poor construction there is sometimes more heat transmitted through the openings about the windows than passes through the glass, and the average radiator in the average installation will not emit more than 240 B. T. U. per sq. ft. per hour.

The practice of apportioning radiation to rooms from their cubic contents cannot be too strongly condemned. It is true that a building figured on such a basis *may* contain the proper amount of radiation in the aggregate, but the distribution of heat *cannot be right except by accident*.

To illustrate the 2—20—200 rule, take a room 15 x 15 x 10, with two sides exposed, each side having a window which contains 30 ft. of glass. This gives us:

	Sq. ft.		Sq. ft. rad.
Glass	60	1 :2	30
Wall.....300-60 equals	240	1 :20	12
Cu. ft. of air	2,250	1 :200	11
			53

Ratio for steam, 1.42.5 cu. ft. of air.
Add for water, 60 per cent. equals 85 sq. ft.
Ratio for water, 1.26.5 cu. ft. of air.

The same room with one side exposed and 30 ft. of glass, figured by the same rule, gives 32 sq. ft. for steam and 51 square feet for water. Ratio for steam 1:70 cubic feet and for water, 1:44 cubic feet. If but one side of the room is exposed which is all glass we would have:

		Sq. ft.
Glass	150 ÷ 2	= 75
Air	2250 ÷ 200	= 11
For steam		86
For water		138

This gives too much radiation as we shall see later.

Now, this rule is all right where there is 70 deg. difference between the outside and inside temperatures, and where the proportion of glass and wall remain nearly constant, but when we want to figure for 20 below, or 40 above zero, with a temperature difference of from 30 to 90 degrees Faht., the rule does not apply, and if we have no other recourse we must guess.

The radiation necessary to warm a given space at any difference in temperature between the two sides (outside and inside), and for any given number of changes of air per hour, can only be correctly determined by computing the loss of heat by cooling or transmission in B. T. U. per hour through the different material, and dividing the sum of the loss by the heat emitted by one square foot of radiation in one hour. This is not so difficult as it may seem, and it is just as easy to learn to do a thing right as it is to acquire the habit of doing it wrong.

The transmission of heat from the interior to the exterior of a room or building through the walls, windows, or ceiling, is calculated in B. T. U. per hour for one degree of difference in temperature on the two sides of the material, as follows:

	Sq. ft.	B. T. U.
8 in. brick wall	1	0.46
12 in. brick wall	1	0.32
Frame construction, (wide range)	1	0.32 to 0.64
Single window	1	1.03
Double window	1	0.52

Ceilings close to roof, same as walls.

For one change of air per hour, we will calculate that one B. T. U. will raise the temperature of 50 cubic feet of air one degree F. Then the cubic contents multiplied by the temperature difference between outside and inside, divided by 50, will give the heat required in B. T. U. per hour to warm the air. If the temperature difference is 70 and the cubic contents 2,250, we multiply the latter by the factor 1.4, which is obtained by the division of 70 by 50. From these co-efficients we obtain multipliers for the varying temperatures as follows:

MULTIPLIERS FOR VARYING TEMPERATURES.

TABLE "A."

Column number	1	2	3	4	5	6	7
External temperature F. Deg	40	30	20	10	0	—10	—20
Internal temperature F. Deg	70	70	70	70	70	70	70
Temperature difference	30	40	50	60	70	80	90
Multipliers, for 1 square foot of single glass	32	42	52	62	72	82	92
" " 12-inch wall	10	13	16	19	22	25	28
" " cu. ft. air (1 change per hour)	0.6	0.8	1.0	1.2	1.4	1.6	1.8
" " " " (2 changes per hour)	1.2	1.6	2.0	2.4	2.8	3.2	3.6
" " " " (4 changes per hour)	2.4	3.2	4.0	4.8	5.6	6.4	7.2
" " " " (6 changes per hour)	3.6	4.8	6.0	7.2	8.4	9.6	10.8
" " double windows	16	21	26	31	36	41	46
" " frame construction, poor	20	26	32	38	44	50	56
" " frame construction, best	10	13	16	19	22	25	28
" " ceiling close to roof	10	13	16	19	22	25	28
" " ceiling with large air space	3.8	5	6.3	7.6	9	10.3	11.5

Be careful to notice that the important factor is the *temperature difference*, and that from zero outside to 50 deg. inside is the same as from 20 deg. outside to 70 inside, etc.

We may now take the room 15x15x10 with 60 feet of single windows, and 240 feet exposed wall, and by the above rule figure the radiation required for an external temperature of 0 deg. internal 70

Glass	60 x 72 =	4,320
12 in. wall	240 x 22 =	5,280
Cu. ft. air	2,250 x 1.4=	3,150
B.T.U. lost per hour................		12,750

For the radiation we will take a low rate of emission to cover all conditions and say that one square foot of steam radiation at 2 lbs. pressure will emit or furnish 240 B. T. U. per hour, and that a hot water radiator at 170 deg. F. will furnish per square foot per hour, 150 B. T. U.

We then have for steam 12,750 divided by 240 = 53 sq. ft., and 12,750 divided by 150 = 85 sq. ft. for water.

The figures for this room for the different outside temperatures with 70 inside, would be as follows:

External temp. F. Deg. 40 20 10 0 --10 —20

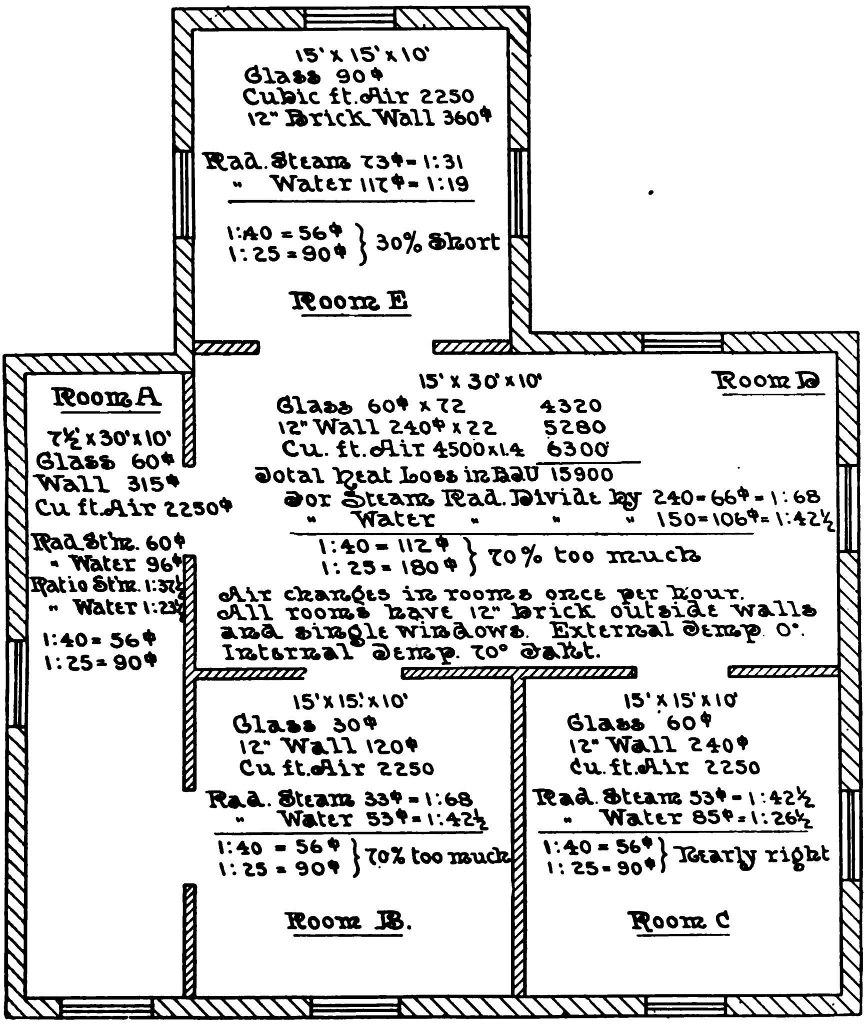


FIG. 2—FLOOR PLAN OF ROOMS HAVING DIFFERENT EXPOSURES—ILLUSTRATING HOW TO FIGURE HEATING TRANSMISSION. (SEE PAGE 18.)

Temp. difference	30	50	60	70	80	90
Steam, sq. ft.	24	38	46	53	60	68
Water, sq. feet	38	61	73	85	96	109
Rad. to cu. ft. of air, steam	1:94	1:59	1:49	1:42.5	1:37.5	1:33
Rad. to cu. ft. of air, water	1:59	1:37	1:31	1:26.5	1:24	1:21

We observe by the above table that to maintain a temperature of 70 deg. in a given room, requires about 80 per cent. more radiation for 20 below, than is necessary for 20 above zero, which is 2 per cent. increase for a drop of one degree.

In making use of this method, it is only necessary to figure a few rooms, which will give the proper ratio to apply to the cubic contents of similar rooms. With but one exposed side all glass we have:

Glass	150 × 72 = 10,800
Air	2,250 ×1.4 = 3,150
	13,950

Divide by 240 gives 58 sq. ft. for steam, divide by 150 gives 93 sq. ft. for water; as against 86 sq. ft. for steam and 138 sq. ft. for water, by the 2—20—200 rule.

It may be asked why we place so low a value on the radiator efficiency when for the purpose of boiler rating we say that steam radiation will emit 300 B. T. U. per square feet per hour, and water radiation 180.

For the latter purpose we take the highest radiator efficiency obtainable under the most favorable conditions, and select boilers to meet those conditions, which will surely make them safe when attached to radiation of lower efficiency.

On the other hand, it is not safe to depend upon so high an efficiency from radiation to replace the heat loss of buildings, because of the varying conditions surrounding the installation of every single radiator.

Radiators yield their highest efficiency under the following conditions:

First—When placed far enough from a wall to allow a free circulation of air over the surface.

Second—Where the change of air in the room is frequent. (Four changes of air per hour will cause a radiator to give off more heat than one change of air.)

Third—When equipped with air valves that insure a clearance of all the air in all of the loops. A matter of importance.

Fourth—When the top is wholly unobstructed to permit a free flow of air the full length of the loops.

And conversely, a radiator will do its poorest work:

First—When placed close to a wall.

Second—Where there are very infrequent changes of air.

Third—When air bound. (A radiator may be hot throughout every square inch of its surface and yet a portion of the surface may contain air heated by contact with the steam, but all such surface will only condense as much steam as the air will absorb, and is, therefore, of low efficiency.)

Fourth—When covered with marble tops, board seats, cushions, or when used as plate warmers, etc.

Fifth—In water heating, where the circulation is reversed and enters the radiator through the return. (A frequent occurrence and one that is sometimes erroneously attributed to undersized mains.)

Sixth—Where the water is drawn from a radiator for domestic use.

Seventh—Where the water stands in the radiator below the top connecting port, and the water in the loops is heated by contact or conduction from the bottom port.

To illustrate the importance of a proper distribution of radiation, we present a floor plan of several rooms (Figure 2), each requiring a different ratio of radiation to cubic feet of air.

These rooms would be figured by heat transmission for the temperatures of zero outside and 70 deg. inside, as follows:

Room "A"—7½ ft.x30 ft.x10 ft.

	Sq. ft.	
Glass	60 x 72	= 4,320
Wall	315 x 22	= 6,930
Cu. ft. air	2,250 x 1.4	= 3,150
Loss in B.T.U. per hour		14,400

For steam, divide by 240 = 60 sq. ft rad.
Ratio for steam, 1.37½ cu. ft. air.
For water, divide by 150 = 96 sq. ft. rad.
Ratio for water, 1.23½ cu. ft. air.

Room "B"—15 ft. x 15 ft. x 10 ft.

	Sq. ft.	
Glass	30 x 72	= 2,160

Wall	120 x 22	= 2,640
Cu. ft. air	2,250 x 1.4	= 3,150

Loss in B.T.U. per hour............ 7,950
For steam, divide by 240 = 33 sq. ft. rad.
For water, divide by 150 = 53 sq. ft. rad.
Ratio for steam, 1.68 cu. ft. air.
Ratio for water, 1.42½ cu. ft. air.

Room "C"—15 ft. x 15 ft. x 10 ft.

	Sq. ft.	
Glass	60 x 72	= 4,320
Wall	240 x 22	= 5,280
Cu. ft. air	2,250 x 1.4	= 3,150

Loss in B.T.U. per hour............ 12,750
For steam, divide by 240 = 53 sq. ft. rad.
For water, divide by 150 = 85 sq. ft. rad.
Ratio for steam, 1.42½ cu. ft. air.
Ratio for water, 1.26½ cu. ft. air.

Room "D"—15 ft. x 30 ft. x 10 ft.

	Sq. ft.	
Glass	60 x 72	= 4,320
Wall	240 x 22	= 5,280
Cu. ft. air..............	4,500 x 1.4	= 6,300

Loss in B.T.U. per hour............. 15,900
For steam, divide by 240 = 66 sq. ft. rad.
For water, divide by 150 = 106 sq. ft. rad.
Ratio for steam, 1.68 cu. ft. air.
Ratio for water, 1.42½ cu. ft. air.

Room "E"—15 ft. x 15 ft. x 10 ft.

	Sq. ft.	
Glass	90 x 72	= 6,480
Wall	360 x 22	= 7,920
Cu. ft. air	2,250 x 1.4	= 3,150

Loss in B.T.U. per hour............ 17,550
For steam, divide by 240 = 73 sq. ft. rad.
For water, divide by 150 = 117 sq. ft. rad.
Ratio for steam, 1.31 cu. ft. air.
Ratio for water, 1.19 cu. ft. air.

Tabulating the different methods of obtaining the requisite quantity of radiation for the rooms shown on the sketch, we can better see how they measure up to the standard obtained by figuring from heat transmission.

	1		2		3	
	By heat trans-mission		By rule 2—20—200		By cu. ft. of air	
					1:40	1:25
	S.	W.	S.	W.	S.	W.
Room A	60	96	57	91	56	90
Room B	33	53	38	61	56	90
Room C	53	85	53	85	56	90
Room D	66	106	64	104	112	180
Room E	73	117	74	118	56	90

No. 2 is almost exactly the same as No. 1.
No. 3 is 18 per cent. greater than No. 1.

Thus, on a building requiring 24,000 square feet of radiation, No. 3 would have a surplus of 4,300 square feet, while some rooms would be too warm, and others too cold.

CHAPTER III.

HEAT TRANSMISSION AND ITS APPLICATION.—Continued.

ONE of the advantages of knowing how to figure from transmission, is that the rule adapts itself to all temperatures. For example, in some parts of California the requirements are to raise the temperature of the air from 40 to 70 deg. F. For room "C" there would be required 24 square feet for steam, or 38 square feet for water.

Again, in some parts of the South, the requirements are to raise the temperature of the air from 20 to 70 deg., and for those conditions room "C" requires 38 square feet for steam, or 61 square feet for water.

The *same class* of building located in the Northwest, where we must prepare for 20 below zero, will require for room "C" 68 square feet for steam, or 109 square feet for water, a difference in radiation requirements between California and Minnesota, of 118 per cent.

With some heating contractors it is customary to increase the proportion of radiation on that side of the building which is exposed to the prevailing winter winds. Others take the ground that if it is zero on one side of the house, it is zero on all sides, and that additional radiation is not required on what is termed "the cold side of the house." Experiments, however, prove that the ratio of radiation must be increased on the windward side of the house to secure an even distribution of heat, not because the heat transmitting qualities of the building material is increased by the force of the wind, but for the reason that the wind pressure forces fresh air into the room, causing a *more frequent change of air*.

Consider a room containing 2,250 cu. ft., where the radiation is figured for one change of air per hour. To warm the air only, 13 sq. ft. must be used. If the air of the room changes twice per hour, the radiation apportioned for warming the air must be doubled, or if the windows are so badly fitted that the wind pressure forces a change of air four times per hour, there would be required for the purpose of warming the incoming air 52 sq. ft. instead of 13.

There are instances where the windows of a room are so badly fitted to the casings, and the casings are so loosely fitted to the wall, that it is seemingly impossible to introduce sufficient radiation to warm the room on cold, windy days, due to the rapid displacement of the air.

The proper remedy in such cases is to put on double windows and close with cement all openings about window frames.

Here is another application of the "transmission" rule:

A factory two stories high is to be warmed with low pressure steam, the first story to 40 degrees, and the second to 70 degrees, when the external air is zero; 12″ brick walls, wood ceiling next to roof, no air space.

The data is as follows:

Building 120 ft. × 40 ft., each floor 12 ft. ceilings, air in rooms change once per hour.

First Floor.

Temperature 40°, temperature difference 40°. See multipliers in table A, col. 2.

Glass	400 sq. ft. × 42	= 16,800
Wall	3,240 sq. ft. × 13	= 42,120
Cubic ft. air	57,600 sq. ft. × 0.8	= 46,080
Total loss of heat per hour in B. T. U.		105,000

Divide by 289 = 363 sq. ft. of radiation.

Second Floor.

Temperature 70°, temperature difference 70°. See multipliers table A, col. 5.

Glass	680 sq. ft. × 72	= 48,960
Wall	3,250 sq. ft. × 22	= 71,280
Ceiling	4,800 sq. ft. × 22	= 105,600

Cubic ft. air .... 57,600 sq. ft. × 1.4= 80,640

Total loss of heat per hour in B. T. U. 306,480
Divide by 240 = 1,277 sq. ft. of radiation.

No account is taken of the loss of heat through the floor in the second story. Strictly speaking, it should be accounted for, as it would lose heat to the first story, but the loss would be small.

The emission of heat from a radiator is proportional to the difference in temperature between the steam in the radiator and the surrounding air. On the first floor the surrounding air is 40 deg., the steam 220, making a difference of 180 deg. On the second floor the surrounding air is 70 deg., and the temperature difference 150 deg. Then, as the radiator emission is 240 B. T. U. per sq. ft. per hour, with a temperature difference of 150 deg., the emission will be 289 B. T. U. with a temperature difference of 180 deg.

We have shown the radiation required on a floor plan, when the external temperature is at zero and the internal temperature 70 degrees; also where the external is zero and internal 40 deg. We will now, by this method, figure the radiation required in certain localities in the South, where the requirements are to warm the air from 30 degrees external, to 70 degrees internal, a temperature difference of 40 degrees. The multipliers for this temperature difference we find in column 2 of the multiplier table "A," which are as follows:

For glass	42
For wall	13
For cubic feet of air................	0.8

The radiation required for the different rooms shown on floor plan, Fig. 108, will then be as follows:

Room "A."

Glass .... 60 sq. ft. × 42 = 2,520
Wall .... 315 sq. ft. × 13 = 4,100
Cu. ft. air .... 2,250 sq. ft. × 0.8 = 1,800

Loss in B. T. U. per hour..............8,420
For steam, divide by 240 = 35 sq. ft. radiation.
For water, divide by 150 = 56 sq. ft. radiation.
Ratio for steam, 1 :64 cu. ft. air.
Ratio for water, 1 :40 cu. ft. air.

Room "B."

Glass .... 30 sq. ft. × 42 = 1,260
Wall .... 120 sq. ft. × 13 = 1,560
Cu. ft. air .... 2,250 sq. ft. × 0.8 = 1,800

Loss in B. T. U. per hour..............4,620
For steam, divide by 240 = 19 sq. ft. radiation.
For water, divide by 150 = 31 sq. ft. radiation.
Ratio for steam, 1 :118 cu. ft. air.
Ratio for water, 1 :73 cu. ft. air.

Room "C."

Glass .... 60 sq. ft. × 42 = 2,520
Wall .... 240 sq. ft. × 13 = 3,120
Cu. ft. air .... 2,250 sq. ft. × 0.8 = 1,800

Loss in B. T. U. per hour..............7,440
For steam, divide by 240 = 31 sq. ft. radiation.
For water, divide by 150 = 50 sq. ft. radiation.
Ratio for steam, 1 :73 cu. ft. air.
Ratio for water, 1 :45 cu. ft. air.

Room "D."

Glass .... 60 sq. ft. × 42 = 2,520
Wall .... 240 sq. ft. × 13 3,120
Cu. ft. air........ 4,500 sq. ft. × 0.8 = 3,600

Loss in B. T. U. per hour..............9,240
For steam, divide by 240 = 39 sq. ft. radiation.
For water, divide by 150 = 62 sq. ft. radiation.
Ratio for steam, 1 :115 cu. ft. air.
Ratio for water, 1 :73 cu. ft. air.

Room "E."

Glass .... 90 sq. ft. × 42 = 3,780
Wall .... 360 sq. ft. × 13 = 4,700
Cu. ft. air .... 2,250 sq. ft. × 0.8 = 1,800
Loss in B. T. U. per hour.............10,280
For steam, divide by 240 = 43 sq. ft. radiation.
For water, divide by 150 = 43 sq. ft. radiation.
Ratio for steam, 1 :52 cu. ft. air.
Ratio for water, 1 :33 cu. ft. air.

Then, again, if the outside temperature is 40 degrees, we proceed in the same manner, except we use the multipliers in column 1, Table "A," which are:

For glass	32
For wall	10
For cu. ft. air......................	0.6

It frequently happens that some room in the house is required to be kept at a lower temperature than others, say at 50 degrees, while all others are at 70 degrees. Without a proper rule the fitter can only guess—but by the use of this method, the radiation can be computed to a certainty.

Suppose a room similar to Room "C" has to be kept at 50 degrees when it is zero outside, the temperature difference is 50 degrees, and we find the correct multipliers in column 3, as below:

Glass .... 60 sq. ft. × 52 = 3,120
Wall .... 240 sq. ft. × 16 = 3,840
Cu. ft. air........ 2,250 sq. ft. × 1.0 = 2,250

Loss in B. T. U. per hour..............9,210

For steam, divide by 240 = 38 sq. ft. radiation.

For water, divide by 150 = 61 sq. ft. radiation.

Ratio for steam, 1 :59 cu. ft. air.
Ratio for water, 1 :37 cu. ft. air.

INDIRECT HEATING.

We will now suppose that room "C" must be warmed with indirect, and that the air will be changed four times per hour. Temperatures are, external 0 degrees, internal 70 degrees, temperature difference 70 degrees; temperature of indirect radiator 215 degrees, the multipliers for glass, wall and cubic feet of air will be found in column 5, and the figures will be as below:

Glass .... 60 sq. ft. × 72 = 4.320
Wall .... 240 sq. ft. × 22 = 5,280
Cu. ft. air....2,250 × 4 = 9,000 × 1.4 =12,600
Loss in B. T. U. per hour.............22,200

For steam, divide by 270 = 82 sq. ft. radiation.

For water, divide by 170 = 139 sq. ft. radiation.

Ratio for steam, 1 :27 cu. ft. air.
Ratio for water, 1 :17 cu. ft. air.

The figures for this room with change of air once per hour, warmed with direct radiation, are—

Steam ....53 sq. ft.
Water ....85 sq. ft.

The indirect for four changes per hour, is –

Steam ....82 sq. ft.
Water ....130 sq. ft.

or 55 per cent. more indirect than direct.

It is customary to guess at the changes of air when using indirect radiation, and to add to the quantity required for direct from 50 to 75 per cent. The example given above will show clearly why it is necessary to use so much more indirect than direct radiation. Many people are under the impression that indirect radiation is much less efficient per square foot than is direct, while, as a matter of fact, the very reverse is the truth. If direct radiation will emit 240 B. T. U. per square foot per hour when surrounded by air at 70 degrees and filled with steam at 215 degrees, then an indirect radiator at a temperature of 215 degrees and receiving the air at zero, ought to emit 355 B. T. U. per square foot per hour, because the emission of heat should be proportional to the difference in temperature between the air and radiator.

In the foregoing example we have not given to the indirect radiator its full value per square foot, because of the well known fact that, due to the many imperfect methods of installation, the efficiency of indirect radiation is often very materially reduced.

Now if the air changes six times per hour, there will not be enough radiation, as the item for cubic feet of air should read—2,250 × 6 = 13,500 × 1.4 = 18,900, an increase in heat required of 6,300 B. T. U., which, divided by 270 for steam equal 23 square feet, and by 170 for water equal 37 square feet, makes the total radiation 105 square feet steam and 167 square feet of water, or practically 100 per cent. more than is required for direct with one change of air per hour.

We have dwelt at length on this subject of frequent change of air, because of its vital importance in determining the proper amount of radiation for the differing conditions.

The air in a room with very loose windows and an aspirating flue, with a strong external wind pressure, will change at least four times per hour, and if the radiation is figured for a change of air once per hour, the room will be cold, and if the man who has to "make good" knows directly where to locate the trouble, much time and expense may be saved.

A rule for computing radiation may be formulated from the foregoing, which will be close enough for all practical purposes.

To the square feet of exposed glass and sash add one fourth of the exposed wall, and divide the sum by 3.

For one change of air per hour, which are the usual conditions, divide the cubic contents of room by 200; the sum of the two items will be the radiation required for low pressure steam.

Example—Room 15 x 15 x 10, two windows—30 feet each—60 sq. ft. Wall 300 less 60 = 240 sq. ft. net. One-fourth of 240 is 60, which is added to the window glass, making 120 feet of glass. Divide by 3 and we have 40 sq. ft. of radiation required to replace the heat lost through glass and walls. 2250 cu. ft. divided by 200 gives 11 sq. ft., which added to 40 makes 51 sq. ft. of radiation.

This is for low pressure steam, to which add 60 per cent. for water heating apparatus.

The divisors may be tabulated thus:

For low pressure steam and 70 deg. temperature difference between external and internal—

Glass, divide by.... .3
Wall, divide by.... .12
Air, divide by...... .200 (one change per hr.)

or the following multipliers may be used, which give a little more radiation:

Glass, multiply by.. .3
Wall, multiply by.. .09
Air, multiply by.... .006 (one change per hr.)

Add 60 per cent. for water heating.

The same results are realized for hot water radiation by dividing glass, wall, and air directly, thus:

Glass, divide by.... .2
Wall, divide by.... .7
Air, divide by...... .120

Above rules are good only for a temperature difference of 70 degrees. For other temperature differences, multiply the radiation derived from the rules given, by the following factors:

30	deg.	temp.	difference	by	.43
40	"	"	"	"	.58
45	"	"	"	"	.65
50	"	"	"	"	.72
55	"	"	"	"	.79
60	"	"	"	"	.86
65	"	"	"	"	.93
75	"	"	"	"	1.08
80	"	"	"	"	1.14
90	"	"	"	"	1.28
100	"	"	"	"	1.42

Example—Suppose the above rule gives 50 sq. ft. to warm a given room where the temperature difference is 70 degrees. How much radiation will be required to warm same room with a temperature difference of 30 degrees, and for a temperature difference of 90 degrees?

Answer—50 times .45 is 22.50, or 22½ sq. ft. for 30 deg. difference.

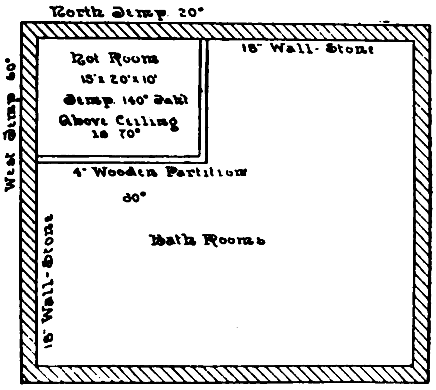
50 times 1.28 are 64.00, or 64 sq. ft. for 90 deg. difference.

The change of air in a room is influenced to some extent by the proportion of cooling surface to cubic contents, and the heating contractor should make some allowance for same.

If the cooling surface (glass and wall combined) is about 5 per cent. of the cubic contents, the air will change from that cause *once* per hour. If the cooling surface is 10 per cent. of the cubic contents, the air will change *twice* per hour. Thus if a room containing 2,400 cubic feet has 60 sq. ft. of glass and 240 ft. exposed wall; one fourth of the wall is equal to 60 ft. of glass, so the total cooling surface is 120 sq. ft., which is 5 per cent. of 2,400 cu. ft. of air.

For high temperatures, such as hot rooms in Turkish baths, the same rule may be used.

If the hot room is in a basement and the temperature is to be kept at 140 degrees while the air in the adjoining rooms is 80 degrees, there will be a temperature difference on the two sides of 60 degrees.



THE HOT ROOM IN A TURKISH BATH

On this page we show the floor plan of a hot room in a bath house. The room is 20 feet by 15 feet by 10-foot ceiling. The temperature is to be maintained at 140 degrees F. The air of adjoining bath room is 80 degrees, beyond the north wall is 20 degrees, beyond the west wall 60 degrees, and above the ceiling 70 degrees.

The loss of heat per square foot of surface per hour for a temperature difference of one degree F. will be for the different walls, as follows:

18 inch stone wall............0.25 B. T. U.
4 inch wood wall.............0.15 B. T. U.
Ceiling ....0.15 B. T. U.

As the air will be changed four times per hour, if it enters at 80 degrees and is raised to 140 degrees, it must be warmed through 60 degrees of temperature, and as one B. T. U. will raise the temperature of 50 cubic feet of air one degree (approximately), then 60 B. T. U. will raise 50 cubic feet 60 degrees, and we obtain the multiplier for the air by dividing 60 by 50, which gives us the factor 1.2.

There are 3,000 cubic feet of air in the room, which will change four times per hour, then 3,000 × 4 × 1.2 gives the heat required in B. T. U. which is 14,400 per hour.

If the steam pipes are at a temperature of 240 degrees, the air being 140 degrees, each square foot will emit 200 B. T. U. per hour, which gives us the divisor for the loss of heat.

The 18-inch wall will have a temperature difference of 120 degrees on the north side and 80 degrees on the west. The wood walls will have a temperature difference of 60 degres, and the ceiling a difference of 70 degrees.

From this data we obtain the following multipliers:

18-inch wall—North	0.25 ×120 = 30
18-inch wall—West	0.25 × 80 = 20
Wood partition	0.15 × 60 = 9
Ceiling	0.15 × 70 = 10.5
Cu. ft. of air	= 1.2

We then take the measurements of the room and compute the pipe required, as follows:

	Sq. ft. Multiplier	B. T. U.
North Wall	200 × 30 =	6,000
West wall	150 × 20 =	3,000
Wood partition	350 × 9 =	3,150
Ceiling	300 × 10.5 =	3,150
Cu. ft. air	3,000 × 4 × 1.2 =	14,400
Total heat loss per hour in B. T. U.		29,700

Divide by 200 = 148 sq. ft. of pipe.

Of this quantity of pipe 72 square feet, or about one-half, is required to warm the incoming air.

The ventilating flue to carry off the air fast enough to insure a change four times per hour, should have an area of 144 square inches.

It is a good plan to have the fresh air enter near the ceiling and leave near the floor line.

It will be plain to all who have followed what has been set forth that from what has been said that the oftener the air is changed the greater will be the quantity of radiation required, and a little figuring along these lines beforehand may save a lot of future trouble and expense to the contractor or owner.

In chapter 2, page 15, referring to the 2—20—200 rule for computing radiation required for low pressure steam heating apparatus, it is stated that where the glass and wall surface are of unusual proportion, or where the difference is other than 70 degrees, the rule has no value.

Let us suppose that the room C—15 x 15 x 10—has 200 sq. ft. of exposed glass and 100 sq. ft. of exposed wall, with one change of air per hour:

200 sq. ft. of glass	1 :2	100 sq. ft.
100 sq. ft. of wall	1 :20	5 sq. ft.
2250 sq. ft. of air	1 :200	11 sq. ft.
		116 sq. ft.

By transmission we get,

200 sq. ft. of glass x $\frac{72}{240}$ equals 60 sq. ft.

100 sq. ft. of wall x $\frac{22}{240}$ equals 9 sq. ft.

2250 cu. ft. of air x $\frac{1.4}{240}$ equals 13 sq. ft.

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In this instance, the 2—20—200 rule gives 40 per cent. too much radiation.

Again figure the same room where the air changes four times per hour—

		2-20-200 Rule.	Transmission Rule.
Glass,	60 sq. ft.	30	18
Wall,	240 sq. ft.	12	22
Air,	2250 cu. ft.	11	52
		53 sq. ft.	92 sq. ft.

Here the 2—20—200 rule provides only 57.5 per cent. of the required radiation.

Again suppose a dry goods store is to be warmed by steam (see floor plans, Fig. A); the shelves are filled with goods of all kinds—woolens, cottons, etc. The windows are double; that is, they are arranged for show windows and are closed off from the store by glass doors. The store is 40 feet wide, 80 feet deep to rear partition and 16 feet from floor to ceiling. The rear portion used for offices is 40 x 15 x 16 ft. ceiling. Glass, wall and cubic contents are as follows:

MAIN STORE.

Glass	700 sq. ft.
Wall	2,560 sq. ft.
Cu. ft. space	51,200 sq. ft.

In the rear office there are of

Glass	144 sq. ft.
Wall	976 sq. ft.
Cu. ft. of space	9,600 sq. ft.

Figuring the 2—20—200 rule, we have for the main store—

			Radiation
Glass	700 sq. ft.	1 :2	350 sq. ft.
Wall	2,560 sq. ft.	1 :20	128 sq. ft.
Cu. ft. space. .	21,200 cu. ft.	1 :200	256 sq. ft
			734 sq. ft
And for the rear offices............			169 sq. ft
Total radiation required for low pressure steam			903 sq. ft
And for water			1,444 sq. ft

Now, inasmuch as there are double windows, the loss of heat will be 36 instead of 72 B. T. U. per sq. ft. per hour, and as the walls are protected by the goods on the shelves, it is fair to assume that the loss of heat will not exceed half that of a bare wall. For the cubic space, we assume one change of air per hour. The main store will figure thus, by transmission:

			Radiation
Glass	700 sq. ft.	x 36	105 sq. ft
		240	
Wall	2,560 sq. ft	x 11	117 sq. ft.
		240	
Cu. ft. space...	51,200 sq. ft.	x 1.4	300 sq. ft
		240	522 sq. ft.
Total radiation for main store.			522 sq. ft.

REAR OFFICES.

144 sq. ft......	x 72	equals 43	
	240		
976 sq. ft......	x 22	equals 90	
	240		
9600 cu. ft. space	x 1.4	equals 56	189 sq. ft
	240		771 sq. ft
Total radiation required for low pressure steam heating and for water			1,135 sq. ft.

In this store, the 2—20—200 rule gives an excess of radiation in the main store of 40 per cent. and a deficiency in the rear office of 12 per cent.

We have assumed that the air in the store would change once per hour but unless there were special ventilators to move the air, it would not be likely to change oftener than once in two hours, in which event only 150 sq. ft. is required to warm the air, making a total of 561 sq. ft.

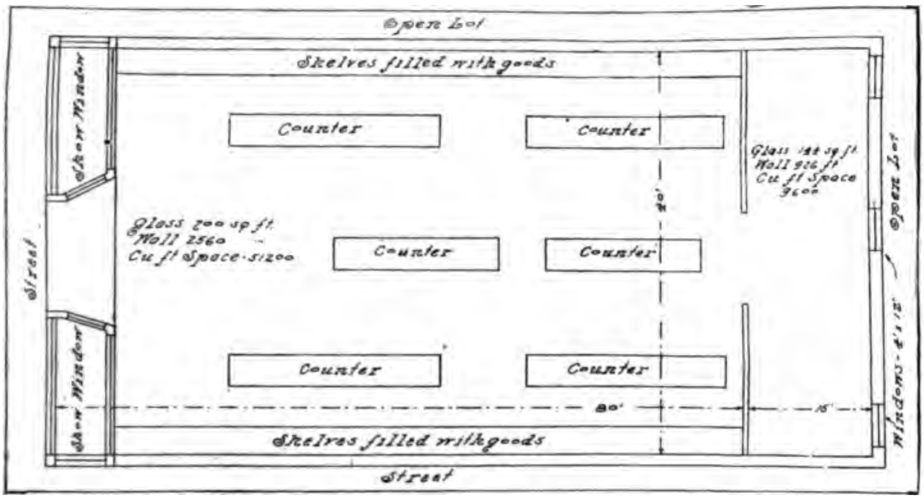

FIGURE A—SHOWING FLOOR PLAN OF THE DRY GOODS STORE

CHAPTER IV.

ESTIMATING MATERIAL AND COSTS FOR STEAM AND WATER HEATING APPARATUS.

ESTIMATES.—The novice in steam or water heating usually finds some difficulty in correctly estimating the cost of a heating apparatus and learns slowly by experience and losses. It is not, however, a difficult matter to make a close estimate of the cost of any house heating job, and a few practical hints along that line may be helpful. The fitter should always have a supply of data and estimate blanks on hand, so that in making his estimate of cost, nothing may be left out, and besides such data is very useful for reference. A very good form is shown on this page. After the amount of radiation has been determined on the data blank, the quantity and price for each kind and height is entered on the estimate sheet. We give below the form for data sheet:

DATA SHEET.

.... HEATING CONTRACTOR.
Owner ....
Building ...., Material................, Size of Chimney Flue ....
Apparatus, kinds .... Date ...., 190...
Height of Ceiling ...., Basement ...., 1st Floor ...., 2d Floor ...., 3d Floor ....
Temperature, rooms ....

Room.	Exposure.	Size of Rooms.	Running Feet Exposed Wall.	Number and Size of Windows.	Air Space Cu. Ft.	Cooling Surface Glass Plus ¼ Exposed Wall Sq. Ft.	Radiation Direct Sq. Ft. Steam.	Water.	Radiation Indirect Sq. Ft.
Item	1	2	3	4	5	6	7		8

NOTE—Item 1 denotes point of compass. Deduct the window openings from square feet of exposed wall; add ¼ net square feet of exposed wall to square feet of exposed glass; then divide item 5 by 200 and item 6 by 3, the sum of the two is the direct radiation required for steam at 2 lbs. pressure when the temperature difference between internal and external is 70° F. For water add 60 per cent.; add for indirect from 50 to 75 per cent.

Then enter the name, number, rated capacity, and net price of boiler.

The next item, pipe and fittings, is a guess, unless piping plans are made, and few care to go to that expense in estimating. The cost of the pipe and fittings will be in proportion to the quantity of radiation and the numbers of radiators. One thousand square feet of radiation divided into ten radiators will take less pipe and fitting than will one thousand square feet divided into twenty radiators.

COST SHEET.

.... HEATING CONTRACTOR.
Owner's Name and Address..
Apparatus, kind .... Date .... 190..

	Est. Cost.	Actual Cost.
1. Boiler, Capacity,		
2. Boiler Pan (where boiler sets below sewer),		
3. Boiler Trimmings, $ Special Grates, $		
4. Brick Work,		
5. Smoke Pipe,		
6. Direct Radiation, per sq. ft.,		
7. Indirect Radiation, per sq. ft.,		
8. Low and Curved Radiation, cost, extra per foot,		
9. Rad. Valves, per Rad., $; Air Valves, per Rad., $		
10. Union Ells, per Rad., $; Floor and Ceiling Plates, $		
11. Pipe and Fittings, per Rad. $		
12. Floor Sleeves, $; Radiator Boards, $		
13. Expansion Tank,		
14. Thermometer, $; Altitude Gauge, $; Regulator, $		
15. Registers for Indirect,		
16. Gate Valves for mains or risers,		
17. Pipe covering, applied, per sq. ft. of radiation,		
18. Boxing Indirects and Air Ducts, Labor and Material,		
19. Decorating Radiators, cents sq. ft.,		
20. Freight, $; Transportation, $; Drayage, $		
21. Labor, Fitters and local car fare, per Rad., $		
21. Labor, Carpenters and local car fare, per Rad., $		
22. Carpenter Work ....$		
23. Men's board and transportation..........		
24. Net Cost Labor and Material,		
25. Cost of doing business, rent, taxes, etc.,		
26. Net Profit,		
27. Bid,		

This work was awarded to ....
Price $..................................

NOTE—20 per cent. added to cost is 16 2-8 per cent. on selling price; 25 per cent. added to cost is 20 per cent. on selling price.

On the other hand, the pipe and fittings for ten radiators spread over a radius of 75 feet would cost about as much as would the pipe and fittings for twenty radiators within a radius of 40 feet.

At present prices (1905) a close estimate of the cost of the pipe and fittings for any given job is 10 cents per sq. ft. of the radiation in a water job. Thus 800 square feet of radiation, at 10c. per foot, is $80. For a steam job figure 7c. per foot of the radiation, which is $56 for 800 square feet.

After a few jobs have been done in a given locality, and an accurate account kept of the costs of the various parts, it will be found an easy matter to estimate very closely the cost of pipe and fittings on all ordinary house heating after the data has been obtained. The next item is radiator valves, union ells, air valves and floor and ceiling plates. These should be estimated at so much per radiator and the average will be close to $1.50 per radiator. Of course if the radiators are connected according to the manufacturers tapping list for water, the above amount will not cover the cost, but in water heating it is seldom necessary to use a valve larger than one inch, though the branch pipe leading to the valve may be 1¼ inch or 1½ inch.

The next item is the drain and feed cock, and here we require the best that can be had. Never use valves for this purpose; obtain a ground plug or steam cock, the best that can be purchased. It will prove less expensive in the end. These will vary in size from ¾ inch to 2 inches, and the cost can be easily obtained. Water boilers are, as a rule, shipped without cocks

The expansion tank should be of ample size and selected according to the table given in Chapter VI. The smoke pipe should be of 16-gage black iron; light galvanized iron does not last long in basements.

Decorating radiators and painting pipes can be done in most sections of the country at a cost of 1½ to 2 cents per square foot of radiation. The item of labor is not so easily estimated because of the wide range in the capacity of different workmen and the facilities for doing the work. It costs much more for labor to install a 12 radiator job in a residence that is under construction, where the work has to be done in installments, than in a building where the work can be finished in one trip; so will the labor of installation in a fine residence be much greater per radiator than it would be in a less pretentious house. Where the workmen measure, cut and fit all the pipe on the premises, it will take a good man and helper about 1¼ to 1½ days to each radiator to finish a water heating job complete, except decorating; that is, a 12 radiator water job should be done inside of fifteen or eighteen days and a 12 radiator steam job should be done in about ten days by one man and one helper.

There should always be a piping plan made of the job and the work should be laid out very carefully, taking care to proportion each part so the circulation of the water or steam will be even.

It is possible, and practical, to measure up a building, lay out the piping, and then go over the building a second time with the plans and take measures for every piece of pipe in the building; this being done, all the pipe can be cut and fitted in the shop by low priced labor, and then taken to the building with the boiler and radiators, where the different parts can be assembled in short order. By this method the labor item can be cut in two. A stray fitter here and there, who is into this scheme, has his competitors on the run and wondering how he does it. The fact is, the labor item in house heating is abnormal and can be greatly reduced without injury to the labor market, for with the cost of labor largely decreased, there will be an increased demand for heating apparatus of real merit.

Too many of the established steam fitting shops depend wholly on their men to lay out the work. They arrive at the amount of radiation and boiler in some way, and sending a load of pipe and fittings to the building tell the fitter to put it in the best way he can.

It is safe to say that under these conditions, the fitter spends half his time waiting for fittings and changing connections, and when the job is in who knows whether it will work until it is tried? We frequently hear contractors complain that the workmen get all there is in it, but that is often their own fault for following such slip-shod methods.

There is no excuse for the workman to-day to cut close, or right and left nipples on the job when the nipples can be bought at the supply house for a mere fraction of the cost of making them.

Another item of expense to the contractors is poor tools. The tongs, stilson wrenches, and cutters, should be looked over and put in good condition after they come into the shop from each job.

In finished and furnished houses, the risers are often run exposed and a careless workmen will often cause his employer a lot of expense by breaking plaster and tramping it over the carpets.

The proper thing to use in such cases is a large drop cloth, such as painters use, which is simply a few yards of cotton sewed together and spread on the floor underneath the place where the cutting is done. To cut the hole in the plaster ceiling, use a pair of sharp pointed dividers with set screw. This will cut the plaster out in a clean, round disk. Cut the lathes with a very fine and very sharp key hole saw. If a coarse toothed saw is used it will cause a vibration that will be likely to crack the plaster. If a lath is loose, hold something against it while sawing. A little care taken in cutting the holes in the ceiling will save a large and needless expense when finishing.

Always use a floor sleeve long enough to reach from the ceiling to the floor above with a margin for turning over onto the floor; put a flange on the bottom to draw up against the plaster, which the ceiling plate will cover. Notch the upper end of sleeve, and flange to floor, which flange will be covered by the floor plate. These sleeves can be made of roofing tin or light sheet iron. They should be made large enough for the pipe to pass through freely and the hole should be cut large enough to accommodate the floor sleeves without forcing them to place. It is best to use ceiling plates which fasten with a set screw, as they are not so apt to slip down. Always arrange to have a little spring on the arm piece at the bottom of the riser so the expansion will be taken care of. If the riser is rigid at the bottom the expansion will be at the top and drive the plate against the ceiling, breaking the plaster. Where pipes run under floors, and where the arms run from the main to the foot of risers, there must be enough pitch to compensate for any expansion and for the settling of the building. In new buildings, it sometimes happens that the job will work all right the first season and give trouble the next owing to some part of the house settling and trapping the pipes.

A short time ago, an experienced heating engineer made a heating plan for a small overhead water job. The work was installed by men of limited experience, and when completed every radiator heated except one line which carried two radiators—these radiators remained cold, when the water was at boiling point. The workman at once said the pipe was too small, and taking out the horizontal part of it in the basement, ran it a size larger. This did no good; they then said the riser was too small, but the owner sent for the man who made the plan before tearing out any more pipe.

The heating engineer said at once that the pipe was either plugged or air trapped in the attic; the latter proved to be true.

The workman had for some purpose placed a board under the outer end of the arm, which elevated it a little more than the diameter of the pipe, causing an air trap which effectually prevented the water passing. When the board was removed and the riser straightened out, it worked as well as any of the others.

CHAPTER V.

PIPING FOR STEAM AND WATER HEATING APPARATUS.

THERE are several methods of piping for both steam and water heating. In water heating the system most in vogue is the flow and return carried side by side near the ceiling joists in the basement, the mains pitching up from the boiler, and the branches pitching up from the mains to the radiators or risers.

In another system the flow main is carried near the basement ceiling, while the return is carried on the wall near the floor, and sometimes is carried back to the boiler under the floor in trenches arranged for the purpose, with wood or cast iron removable covers; or the flow main may have its highest point where it rises from the boiler, being air vented at that point, and pitch down from the boiler to its furthest point, where it drops to the floor and connects with the return, making a continuous circuit from the top of, and back to, the bottom of the boiler, the return risers dropping to the return main.

In the one-pipe circuit system, the main is taken from the top of the boiler and is carried around the basement overhead until it reaches the boiler, where it drops and is connected to the return. In this system the high point is where the main rises from the boiler, and the flow branches are taken from the top of the main while the returns enter on the side. This system is employed very often.

Then there is the overhead system in which the main flow pipe rises to the attic where the mains are distributed, and from which the risers drop to the basement and are there connected to the return main. In this system it is usual to connect the radiators at the top and bottom to one riser, which does very well in buildings of two or three stories.

In all overhead work, however, the best results are obtained by running separate returns from the radiators, as we get a more even distribution of the heat on the different floors than is possible where the flow and return water occupy the same rising line.

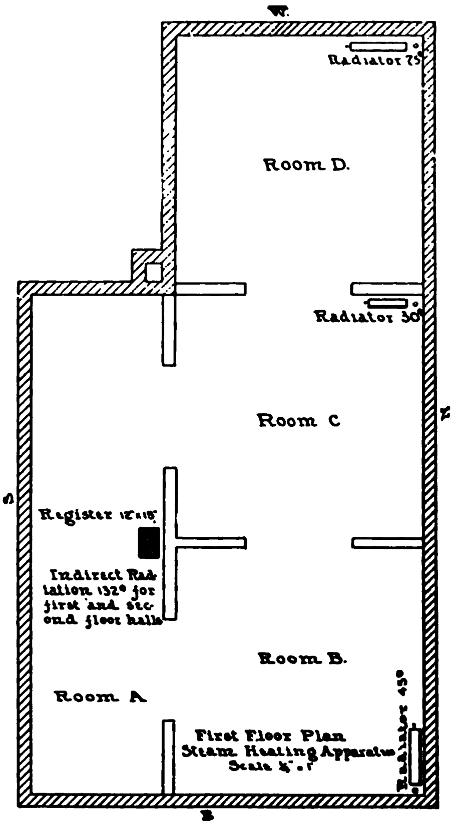

FIG. 3—FIRST FLOOR PLAN LOW PRESSURE HEATING STEAM APPARATUS

The overhead system is best adapted to city built flats where the only exposures are front and back of the building for the reason that the pipe lines can be run to the extremities of the building and the hot water delivered at the cold points first. The lines for the middle of the house and the protected rooms can then be run back so that the coldest rooms will be the first to heat and the last to cool down.

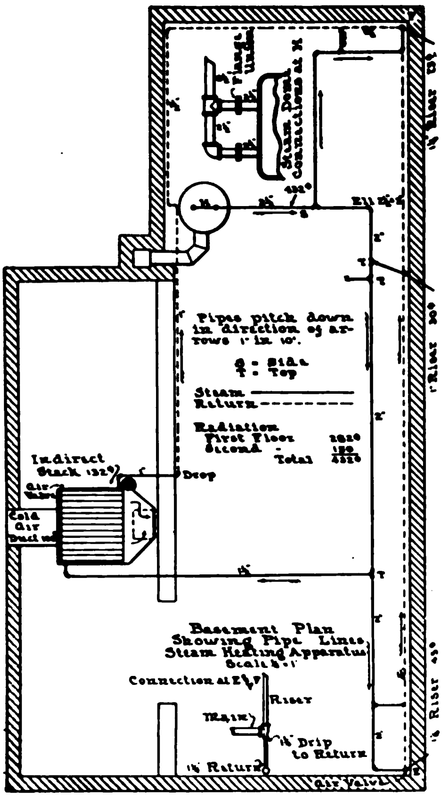

FIG.4—BASEMENT PLAN SHOWING PIPE LINES IN ONE PIPE SYSTEM

An illustration of these different methods of piping will be shown in another chapter.

In low-pressure steam heating there are two general systems in use, known as the one-pipe and the two-pipe systems. The one-pipe system is employed almost exclusively west of New York State, while the two-pipe system seems to have the preference in some parts of New England. If a one-pipe job is properly proportioned and dripped at the necessary points it will give as good results as can be obtained from any two-pipe work, with the advantage of but one valve to manipulate on the radiator instead of two.

In Fig. 3, which is the same floor plan at Fig. 1, page 13, we show the amount of radiation required for a low-pressure steam heating plant figured according to the rule described in a former article.

In Fig. 4 we show a basement plan with boiler, piping and indirect stack. This is a one-pipe system with the exception of the indirect, which has a separate return to the boiler, owing to the fact that this radiator will condense a great deal more steam per square foot than will the direct radiators.

The writer believes that too little attention is given by the great majority of heating contractors to what may be called "the refinement of steam heating." The public have an idea that hot water heat-

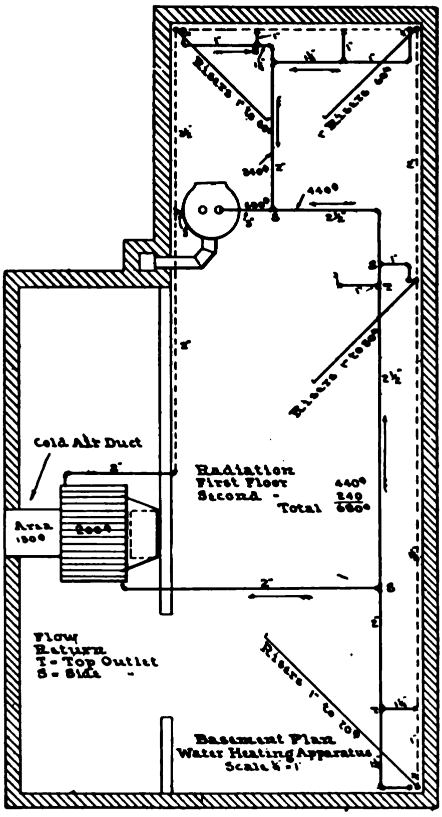

FIG. 5—PLAN ARRANGED FOR HOT WATER HEATING

ing is unquestionably the best thing for residence work, because of their experience with office heating. If, however, they make the comparison with the modern practice of office heating where a vacuum system is employed, governed by thermostatic regulation, the verdict would be in favor of vacuum steam heating; it will only be a short time before a refined system of steam or elastic water vapor heating will largely take the place of hot water heating, in dwellings, for the reason that the radiators take up much less room in the house the work can be done at a much less cost and the danger of leaks is entirely eliminated.

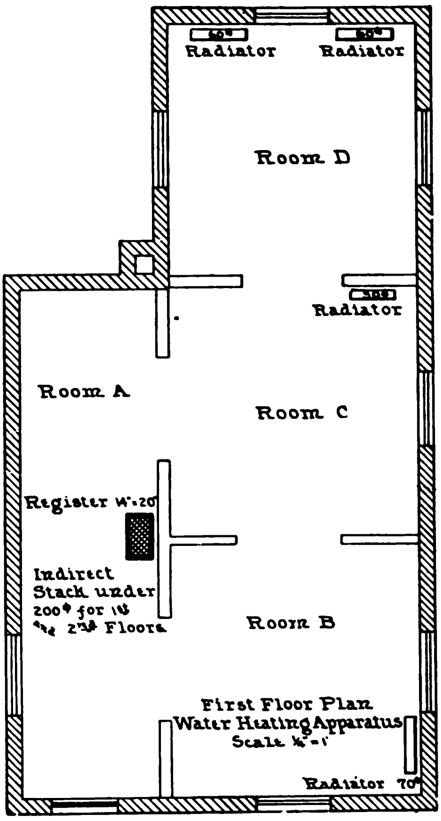

FIG. 6—SAME AS FIG. 3, EXCEPT ARRANGED FOR HOT WATER HEATING

In Figs. 5 and 6 are shown the same set of first floor and basement plans arranged for a hot water heating apparatus. The radiation is obtained by adding 60 per cent. to the radiation required for the low-pressure steam plans.

The flow main is run near the ceiling, the return near the floor on the wall, and all the returns from the radiators are dropped to the return main, and enter the side of the main.

This is done to prevent the return water from a small radiator flowing along the return main, entering the return of a larger radiator and checking the circulation. This frequently occurs and gives the fitter at times a great deal of trouble.

The chimney flue for an apparatus of this size should be 40 feet high from the boiler grates to the top. The area, if round and smooth, should be 70 square inches; if square, the area should be 100 square inches.

The boiler for this apparatus should be round with free flues. It should have about 3 square feet of grate area, 54 square feet of heating surface, and the fire-pot should be deep enough to contain 180 pounds of anthracite coal.

CHAPTER VI.

PIPING FOR WATER HEATING APPARATUS.

IN a water heating apparatus, an expansion tank must be provided and placed above the highest radiator. The volume of water increases with the temperature, and the tank is to take care of this increase in volume.

It is usual to figure that the increase is about 4 per cent. and making a rough guess of the number of gallons contained in a given apparatus, select a tank a little larger than the supposed requirements with the results that the tanks so selected are often too small. The sizes given in the following table are larger than are usually recommended but none too large to meet all conditions.

Sq. ft. of Radiation.	Expansion Tank, Capacity in Gallons.
300	15
500	20
750	26
1,000	32
1,500	42
2,000	66
3,000	100

If the tank is placed in a room where there is no danger of the water freezing, it is sufficient to connect the tank with 1-inch or ¾-inch pipe to the nearest return. If the tank or the pipe leading to it should freeze the expansion of the water would burst some part of the apparatus, and to prevent this, run one pipe to the nearest flow and one from the nearest return and connect under the tank.

The overflow should be run back to a drain or sink in basement and a small vent pipe carried from the top of tank into a ventilating stack or chimney; as the vent pipe is to prevent syphonage, it is not good practice to run it outside as is frequently done, as it might fill with snow and ice.

The overflow pipe should not be run to bathroom tank as is sometimes done, because of the liability of the water boiling and steam escaping into the room.

Fig. 7 shows how the tank should be arranged to prevent freezing.

Fig. 8 shows a very common method of connecting, first and second floor radiators and the trouble that frequently occurs from such practice.

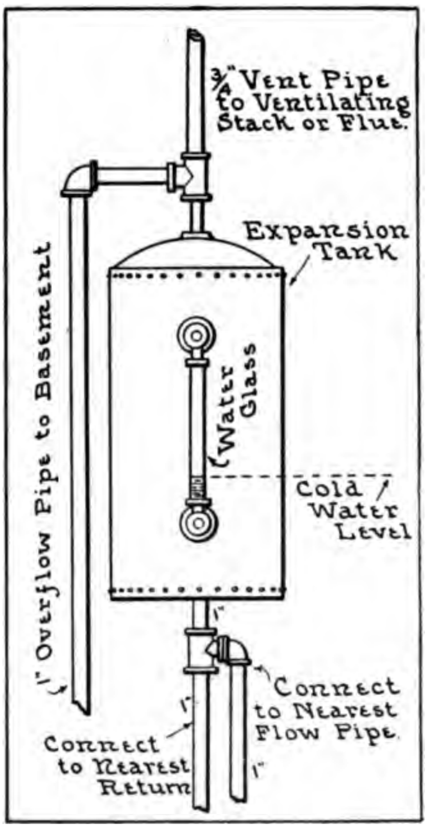
¾" Vent Pipe to Ventilating Stack or Flue.
Expansion Tank
Water Glass
Cold Water Level
1" Overflow Pipe to Basement
1"
Connect to Nearest Flow Pipe.
1"
Connect to Nearest Return
1"

FIG.7—HOW THE TANK SHOULD BE ARRANGED TO PREVENT FREEZING

In the example shown, the first floor

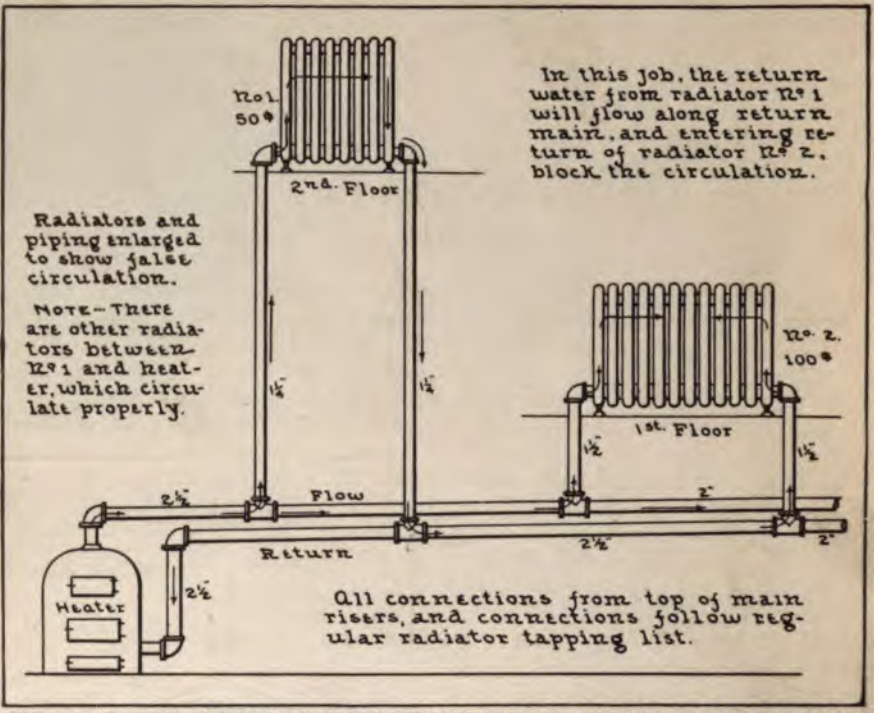
No. 1
50 □'
2nd. Floor
In this job, the return water from radiator No. 1 will flow along return main, and entering return of radiator No. 2, block the circulation.
Radiators and piping enlarged to show false circulation.
NOTE—There are other radiators between No. 1 and heater, which circulate properly.
No. 2.
100 □'
1st. Floor
1½"
1½"
1½"
1½"
2½"
Flow
2"
2½"
2"
Return
2½"
Heater
All connections from top of main risers, and connections follow regular radiator tapping list.

FIG. 8—A FAULTY METHOD OF CONNECTING FIRST AND SECOND FLOOR RADIATORS

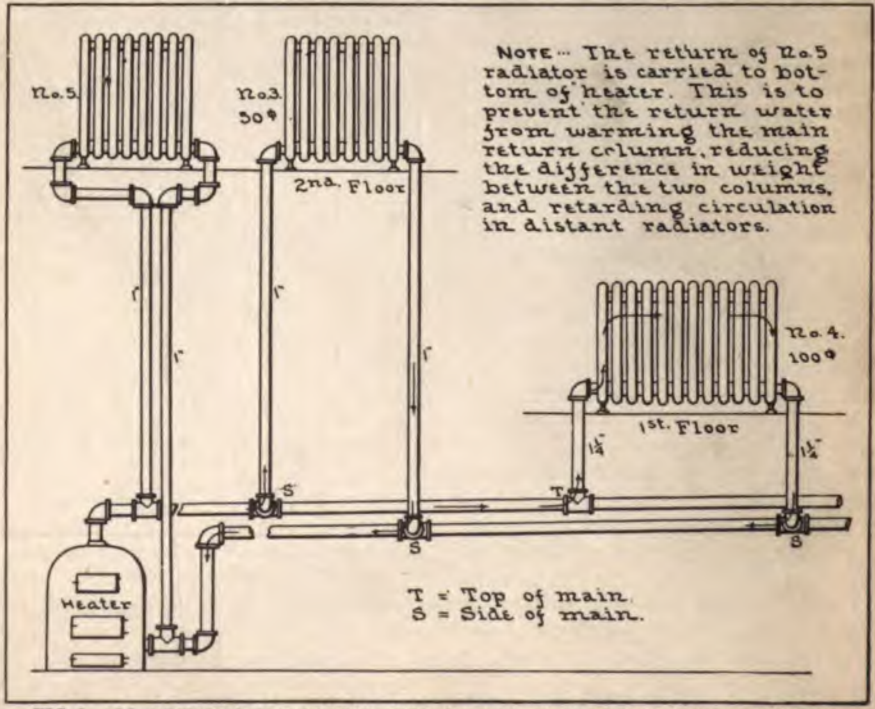
No. 5
No. 3
50 □'
2nd. Floor
NOTE—The return of No. 5 radiator is carried to bottom of heater. This is to prevent the return water from warming the main return column, reducing the difference in weight between the two columns, and retarding circulation in distant radiators.
No. 4.
100 □'
1st. Floor
1"
1"
1"
1"
1½"
1½"
S
T
S
S
Heater
T = Top of main.
S = Side of main.

FIG. 9—ALL RETURNS CONNECTED INTO SIDE OF RETURN MAIN, BETTER WORK

radiator contains 100 square feet, the second floor 50 square feet. Now as the piping is arranged, the upper radiator heats first, and the water returning from it enters the return main at the top and naturally creeps along the top of the main toward the first floor radiator, because the main inclines upward in that direction, and circulation toward the boiler has not yet been established. The large radiator has not had time to heat throughout its length before the return water from the second floor enters its return end and blocks the regular flow, preventing the radiator from attaining its normal temperature. If the small radiator were below and the large one above, then the return water from the small radiator would be likely to enter the return riser and stop the circulation in the upper radiator.

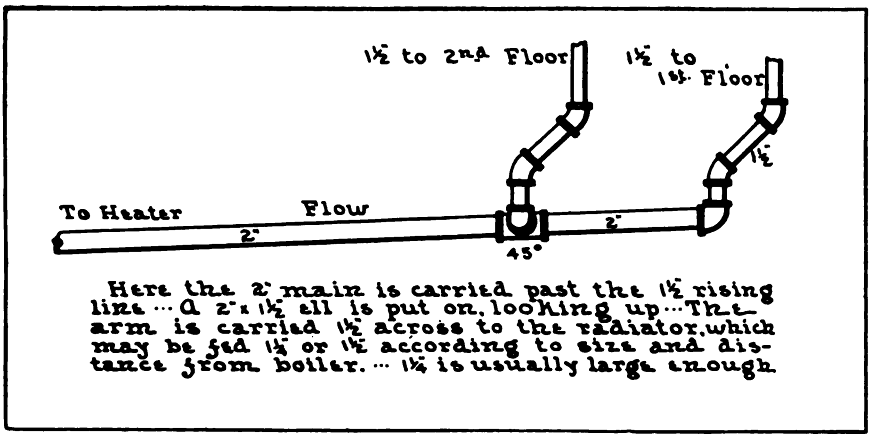
1½ to 2nd Floor
1½ to 1st Floor
1½
To Heater
Flow
2"
2"
45°
Here the 2" main is carried past the 1½ rising line ... a 2" x 1½ ell is put on, looking up ... The arm is carried 1½ across to the radiator, which may be fed 1¼ or 1½ according to size and distance from boiler. ... 1¼ is usually large enough

FIG. 10—METHOD OF RUNNING MAINS AND BRANCHES WHICH FREQUENTLY CAUSES TROUBLE

The remedy is to keep the return water from the small radiator in check until circulation shall have been established in the large one.

This is best accomplished by taking the flow riser for the small radiator out of the side of main and connecting all returns into side of return main. See Fig. 9.

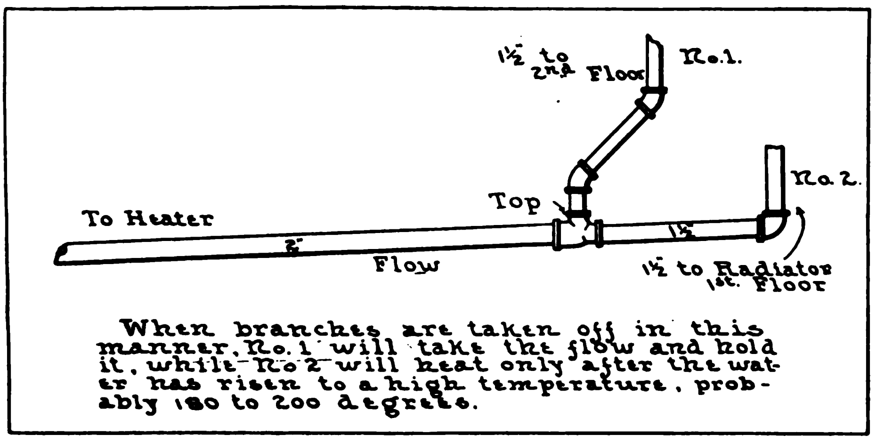
1½ to 2nd Floor
No. 1.
No. 2.
Top
To Heater
2"
1½
Flow
1½ to Radiator 1st. Floor
When branches are taken off in this manner, No. 1 will take the flow and hold it, while No 2 will heat only after the water has risen to a high temperature, probably 180 to 200 degrees.

FIG. 11—SHOWING WHERE THE BRANCH IS TAKEN OFF AND THE MAIN IS CONTINUED IN A REDUCING ELL. AN IMPROVEMENT OVER FIG. 10

Another method of running mains and branches which frequently causes trouble is shown in Fig. 10.

Here the main reduces from 2-inch to

1½-inch and as the first radiator branch is taken off the top, the radiator on the end of the line will remain cold until the water is at a very high temperature.

If an eccentric tee were used it would help some, but a better way is shown in Fig. 11, where the 1½-inch branch is taken off 45 degrees and the 2-inch main is continued to a reducing ell 2 x 1½ inches. The reducing ell can look up and the 1½-inch pipe be carried as far as desired with the assurance that it will receive its quota of heat at any and all temperatures.

One of the requirements of a good water heating job is that all the radiators shall heat evenly when the initial temperature is 120 degrees, but if this test were generally applied, many jobs would fail to make good.

CHAPTER VII.

OVER-HEAD SYSTEM FOR WATER HEATING APPARATUS.

FIG. 12, on page 38, shows a flat building piped for an overhead water heating apparatus. The sizes given for the various radiators are not proportioned to any given room, but show the relative size for each floor. As the water is carried to the attic first, the hottest water will be delivered to the top floor, but as the top floors will lose heat faster than the lower floors, owing to the cooling action of the roof, we give that floor nearly as much radiation as the second floor, but increase on the first floor, where the water is coolest.

The radiators attached to riser No. 1 have a separate return, which is unquestionably the proper way to connect radiators on overhead work, because of the more equal temperature of the water in the line.

All the other radiators are shown connected up to one line, which is the usual method.

Radiator A is shown connected to the main riser, simply to show what can be done in an emergency, such as a bathroom radiator where the main riser runs through the room. A radiator so connected will heat all right, but, of course, it should only be applied to one or two small rooms.

The feed pipe to top of radiators is taken off the riser so as to get a swing joint, and the returns are taken off under the floor, and rise to the radiator valve. This is done to avoid rigid connections, which are very difficult to make, as those who have tried them can testify. See details, Fig. 13.

In the attic, we connect first to the front line and then run back and connect up the center lines. In this way we get the heat first and last where it is most needed.

The expansion tank should be of extra size; 100 gallons is none too large, as we require a good reservoir of water in the attic, and only half of the tank can be filled with water if laid on its side, which is the usual method for want of space.

The overflow should be run to a convenient sink in basement, and a vent pipe to a stack in attic.

If it is desired to put a little pressure on the job, this can best be done by placing a good safety valve on the overflow pipe in attic and running a chain or strong copper wire, from the valve to basement over a pulley, so that pulling on the wire will lift the valve, and allow the air to escape. If this is done, there is no need of the ½-inch vent pipe. A pan should be placed under the safety valve to catch any leakage or splash of water. When the apparatus is arranged in this way, it is only necessary in filing to raise the safety valve, turn on the water pressure, and when it flows at the overflow pipe, the entire apparatus will be filled.

One of the advantages of the overhead system is that the air is taken care of automatically.

Another important feature is rapid circulation, which returns the water to boiler with the minimum loss of heat. If the water returns to the boiler 40 degrees below the outgoing temperature, more fuel will be required to restore the lost heat than where the difference is only twenty degrees.

In regard to the piping, the main flow pipe will easily take care of double the radiation in overhead work that it will in basement piping.

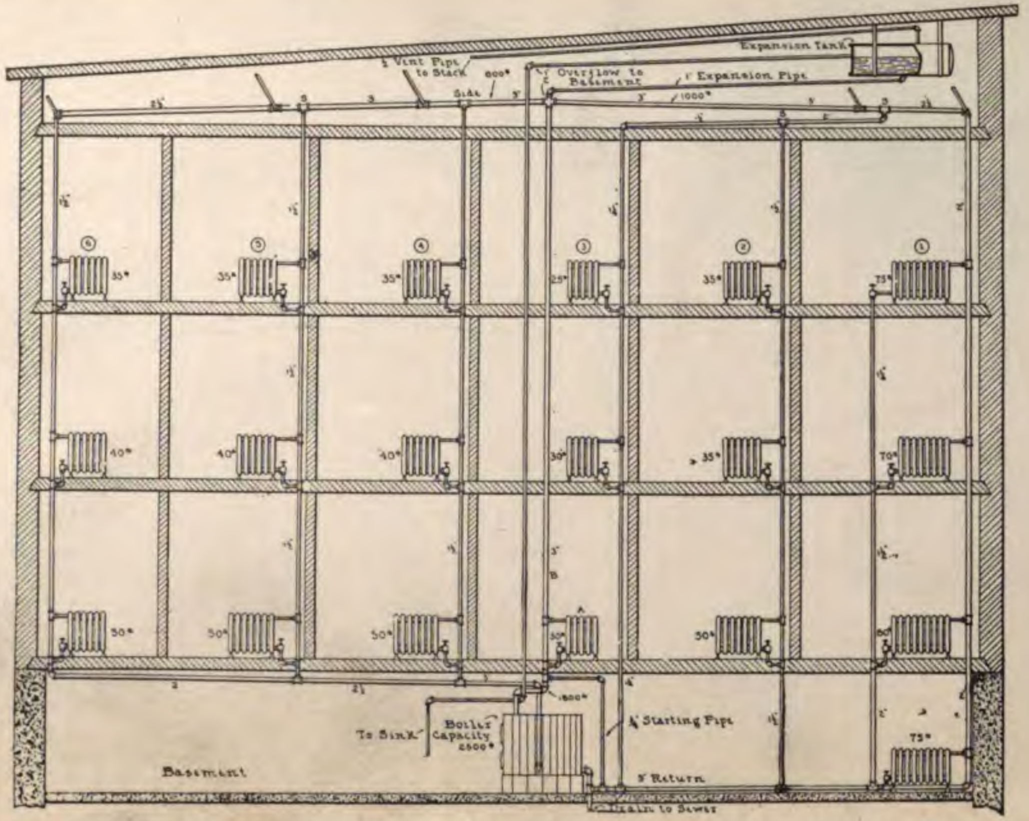

FIG.12—SECTION OF A FLAT BUILDING WATER HEATING—OVERHEAD PIPING. ONLY ONE-HALF OF RADIATION SHOWN IN THIS ILLUSTRATION

The following table is based on good practice in overhead water heating, and gives the quantity of radiation in square feet that can be attached to the various sizes of pipe.

Main Riser from boiler.		Drop Riser Single.	Drop Riser Separate Return.
¾"		25	50
1"		80	120
1¼"		120	200
1½"	350	200	350
2"	600	400	600
2½"	1200	750	1200
3"	2000	1000	
3½"	2500		
4"	3500		
4½"	4500		
5"	6000		
6"	10000		
7"	12000		
8"	15000		

When the main riser is carried to the attic, it is a good plan to connect it to a piece of large pipe, which acts as a reservoir, and from which the horizontal lines may be run; in this way it is safe to take three pipes from the reservoir, each pipe being of equal area to the main riser, see sketch, Fig. 15. Fig. 16 is taken from actual practice, where the plant has been in successful operation for seven years.

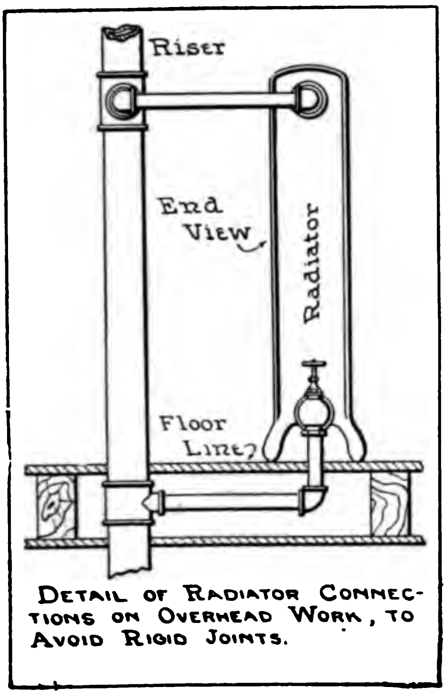
Riser
End View
Radiator
Floor Line
Detail of Radiator Connections on Overhead Work, to Avoid Rigid Joints.

FIG. 13—DETAIL OF RADIATOR CONNECTIONS ON OVERHEAD WORK, TO AVOID RIGID JOINTS

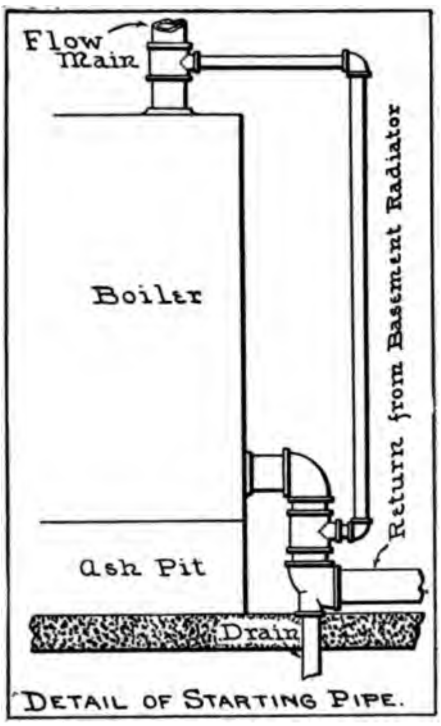

FIG. 14—DETAIL OF STARTING PIPE

The starting pipe shown in detail in Fig. 14 is very important where there are radiators on same level as the boiler. The object in using this pipe is to heat and consequently lighten the water in the pipe which rises from the floor to boiler return. This lift is usually 18 inches to 24 inches, and, being the coldest and heaviest column of water in the apparatus, retards the easy flow of the water in that line, and as a consequence the lower half of the basement radiator is likely to be away below normal temperature.

All branches in attic must be taken out of side and pitch down, so there shall be no air traps.

Boilers for water heating apparatus should have thin waterways, though such boilers are not easily obtained, as than are desirable for water heating only. The radiation attached to boiler in Fig. 11 is 1,800 square feet; adding 20 per cent., which will cover the piping in overhead work, gives as the boiler load 2,160 square feet, for which we require a boiler and stack of the following proportions:

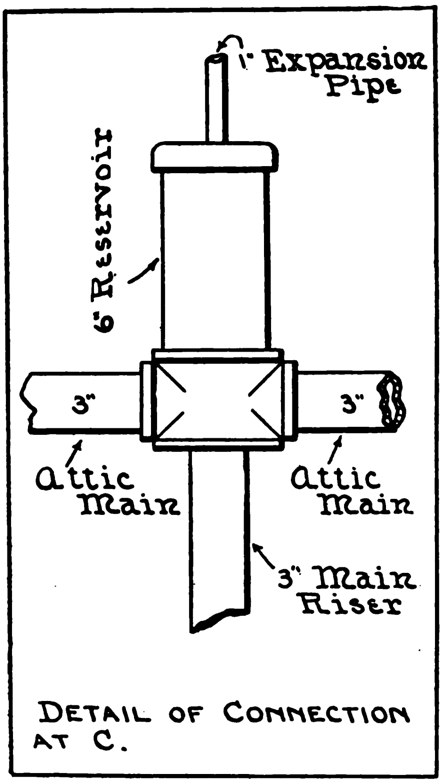

FIG. 15—DETAIL OF CONNECTION AT C. FIG. 12

Heating surface in boiler (60 per cent. direct). Ratio: 1 sq. ft. heating surface to 16 sq. ft. of radiation, requiring 135 sq. ft. of heating surface.

Grate surface, ratio: 1 sq. ft. of grate to 18 sq. ft. of heating surface, requiring 7.5 sq. ft. of grate.

Fuel capacity, anthracite coal, 500 pounds.

Area of round chimney, 60 feet high, 154 square inches.

Square chimney 60 feet high, 14"x14", or 196 square inches.

The fuel capacity is computed by assuming that there will be fair combustion and that in the most severe weather the radiation and piping will be maintained at a mean temperature of 170 degrees, and that the surrounding air will be 70 degrees Faht.; under such conditions one pound of anthracite coal of good quality will take care of 5.4 (five and four-tenths) feet of radiation for eight continuous hours and, as we have 2,160 feet attached to the boiler, 400 pounds will be consumed in eight hours, and for a reserve 100 pounds is not too much. Therefore, the boiler should have 500 pounds hard coal capacity. If the radiation is run at 150 degrees mean temperature in 70 degrees of air, the coal consumption for eight hours will be 322 pounds, and if at 120 degrees it will be 240 pounds. In the Northern States from one to one and a half tons anthracite coal will take care of 100 square feet of water radiation for the season of seven months. The apparatus described in this chapter should run through the season with less than 25 tons anthracite coal.

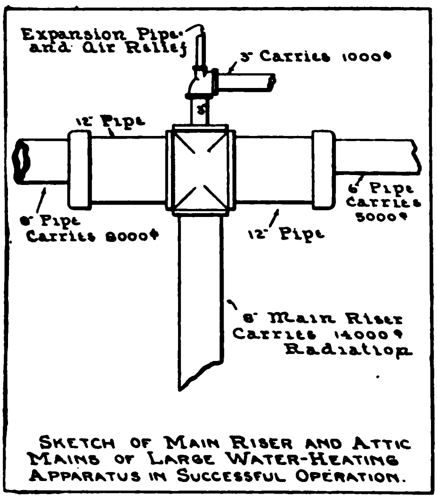
Expansion Pipe and Air Relief
3" Carries 1000#
3"
12" Pipe
6" Pipe Carries 5000#
8" Pipe Carries 8000#
12" Pipe
8" Main Riser Carries 14000# Radiation
Sketch of Main Riser and Attic Mains of Large Water-Heating Apparatus in Successful Operation.

FIG. 16—SKETCH OF MAIN RISER AND ATTIC MAINS OF LARGE WATER-HEATING APPARATUS IN SUCCESSFUL OPERATION

CHAPTER VIII.

PLANS OF A SUCCESSFUL OVERHEAD WATER HEATING APPARATUS IN A THREE-STORY APARTMENT BUILDING.

FIGURES No. 17 to 21 are basement, attic and floor plans of a first-class, modern apartment building.

This is a detached building fronting south. It is well built, of brick construction.

The building is heated with hot water, circulating through an overhead pipe system. The basement is 8 feet in the clear; the first, second and third floors are 10 feet in the clear, and the attic is 7 feet, on an average.

The attic was provided for the double purpose of storage and to provide ample room for the overhead system of piping. As the rooms are all drawn to scale, those who are interested can figure them up and determine for themselves the ratio of radiation to space. The entire radiation in the building is 3,332 square feet of direct and 150 feet of indirect, all located as shown on the plans. The flow and return pipes, together with the risers, amount to 816 square feet, giving a total of 4,298 feet for which we have to provide boiler power.

There are two round boilers used, each of which has a fire chamber, of 38 inches diameter, giving 7.8 square feet of grate. The outside diameter of the heaters is 45 inches, and the total height 68 inches. The rated capacity of each of these boilers in the maker's catalog is 2,400 square feet.

Starting at the basement, the two boilers are cross connected with 4-inch pipe. These two 4-inch pipes, one from each boiler, are connected to a 4-inch main riser, which runs to the attic and carries all of the radiation with the exception of 150 square feet of indirect. That is, this 4-inch riser has attached to it 3,332 square feet of cast iron, hot water radiation. The area of a 4-inch pipe is 12.5 square inches. The combined area of the branches taken from the main in the attic is 34 square inches. The combined area of the valve openings into all the radiators is 36 square inches. It will thus be seen that the 4-inch riser which carries the radiation is only about one-third the combined area of the branches or radiator openings. We call particular attention to this because so many writers, and some architects, persist in specifying that in water heating apparatus the area of the main shall be equal to the combined area of all the branches. In this particular installation, this would have called for a 7-inch main riser as the nearest commercial size. This, again, would have increased the size of all the mains and risers unnecessarily, and added very materially to the cost of the apparatus.

The heating apparatus was installed in this apartment building in the autumn of 1894 and has, therefore, been in use for many seasons, and during that time the only expense incurred was the cost of some grate bars for the boilers. No change whatever was made in any part of the radiation or piping.

The owner of this building is very particular, and in the specifications was embodied an agreement that there should be held back from the contractors $200 until the apparatus had been tested through the months of January and February. During this period it was stipulated that the apparatus should be capable of keeping the temperature of each and every room, including the kitchens, at 70 degrees during the coldest weather.

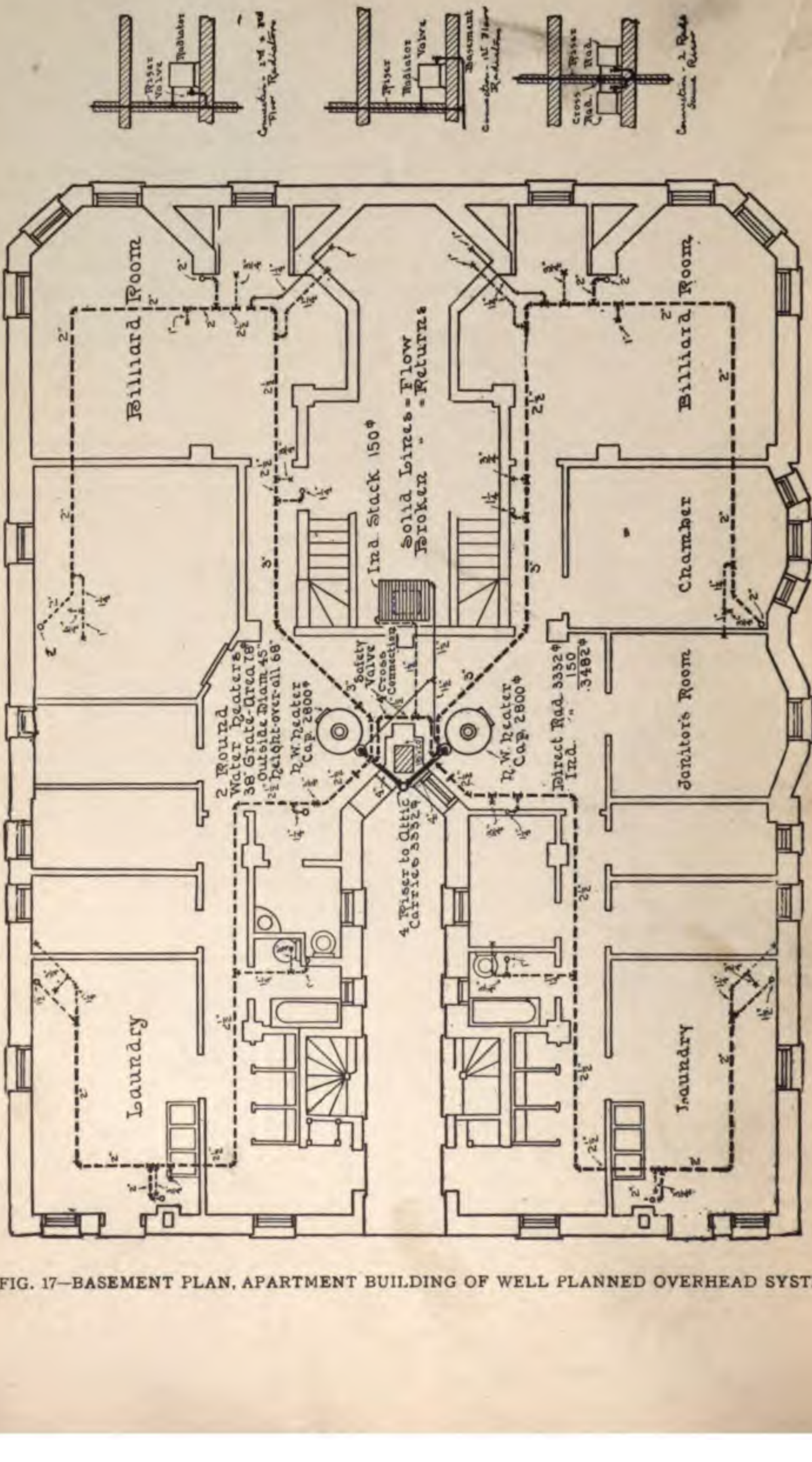

FIG. 17—BASEMENT PLAN, APARTMENT BUILDING OF WELL PLANNED OVERHEAD SYSTEM

During that trial the thermometer was 10 or 12 degrees below zero on two or three different occasions, but the building was so easily kept warm that before the end of the stated period the money was paid to the contractors, and the owner expressed himself as thoroughly pleased with the entire apparatus.

We mention this point simply to prove that the proportions of piping, as shown on the heating plans, are of sufficient size for the apparatus.

The capacities of the risers are as follows: The 2-inch risers, dropping from the attic pipes to the basement, have attached to them on the different floors 497 square fet; the 1½-inch risers have 203 square feet; the 1¼-inch have 91 square feet, and the 1-inch 63 square feet. To each of the 2-inch and 1½-inch risers are connected six radiators. To each of the 1¼-inch and 1-inch, three radiators.

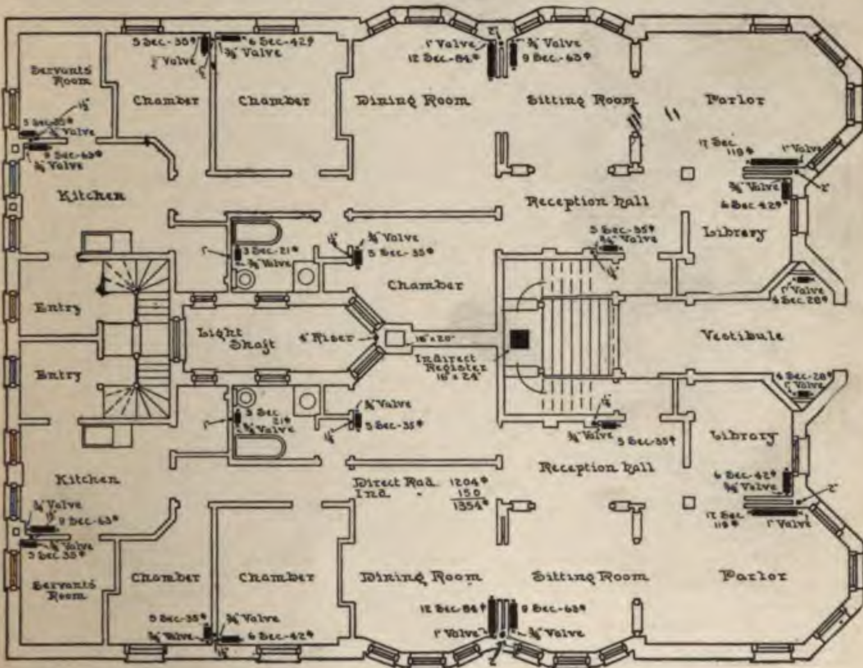

FIG. 18—FIRST FLOOR PLAN OF AN APARTMENT BUILDING. CEILING, 10 FT. HIGH

The piping in the attic is covered. The basement piping is left uncovered as they wanted the benefit of the heat from it for the billiard rooms and laundry.

The expansion tank in the attic is connected in a somewhat unusual manner. The tank has a capacity of sixty gallons, being unusually large, and is used without an overflow pipe. As will be seen by the drawing, it is provided with a special, automatic valve, which is set about the middle of the tank. In filling the apparatus, as the water rises, the air is carried up to the top of the 4-inch main riser, and thence into the expansion tank, where it escapes through the automatic air valve. The water will rise in the tank until it reaches the air valve, which is provided with a float that closes and prevents any leakage. This leaves the upper half of the tank filled with air, which acts as an elastic cushion for the expansion of the water and provides for carrying a temperature above the boiling point when necessary. In other words, this is a modified "close system." When the water is below the air valve the system is "open"; when the water line is high enough to close the valve the system is "closed" and compresses the air in the tank as it expands, an excellent feature indeed.

To guard against any accident of leakage about the tank, there was placed under it a galvanaized drip pan, which was connected by a drip pipe to the basement.

On the return pipe, where it connects to the boilers, there is placed a 2-inch pop safety valve of the best quality. The office of this safety valve is to guard against any possible accident in the event of excessive pressure. The apparatus and expansion tank, however, are so designed that the possibilities of a pressure rising more than twenty pounds above the static head are very remote, and in over ten years' practice, the safety valve has never been in action.

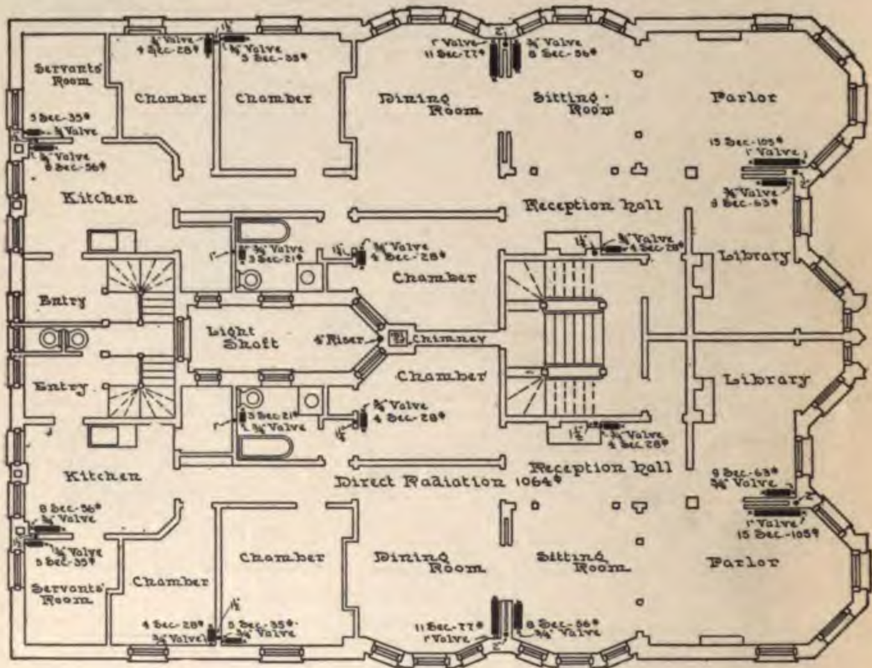

FIG. 19-20—SECOND AND THIRD FLOOR PLAN OF APARTMENT BUILDING. CEILING, 10 FT. HIGH

In this installation there are 68 radiators. Fourteen of them are connected with 1-inch valves and fifty-four with ¾-inch. It will be noticed that the largest radiators contain 119 square feet, and yet they are fed with a 1-inch valve. The two small radiators in the vestibule, containing 28 feet each, are also fed with a 1-inch valve. The reason for using the 1-inch valves on the small radiators is because they are situated in the vestibule next to the front door in a very cold location, and, as a consequence, will cool very quickly. A second reason is that the feed for these two radiators is taken off a horizontal return where the water is at its lowest temperature. The large radiators being fed off a vertical line coming from the attic, will heat just as well with a 1-inch valve as with a larger one, and the use of these small valves and connections of course reduces the cost of construction and labor as well.

The chimney is 18 inches by 20 inches and 55 feet high, which gives an excellent draft.

In locating the radiators, they were placed, whenever practicable, on a partition wall close to the outside walls or windows, and we consider this a better location for radiators than when they are placed against the outside wall.

The radiators were decorated with Japans, or radiator enamels as they are called, and in tints that harmonized with the walls of the room in which the radiators were placed. Very little bronze was used; in some rooms none at all but, instead, two harmonious colors of enamel. With this style of decoration the radiators were not conspicuous, as they would be if decorated with gold bronze or some glaring color. The importance of harmonious decoration of radiators is sadly overlooked by the great mass of heating men, but a moment's reflection will convince anyone that the radiators in the rooms are the only part of the work which is seen by his prospective customers, and if the radiators are tastefully decorated the appearance to the eye will create a good impression while, on the other hand, if radiators are daubed up with maroon Japan and a cheap bronze the appearance of the work does not reflect credit upon the man who installed it.

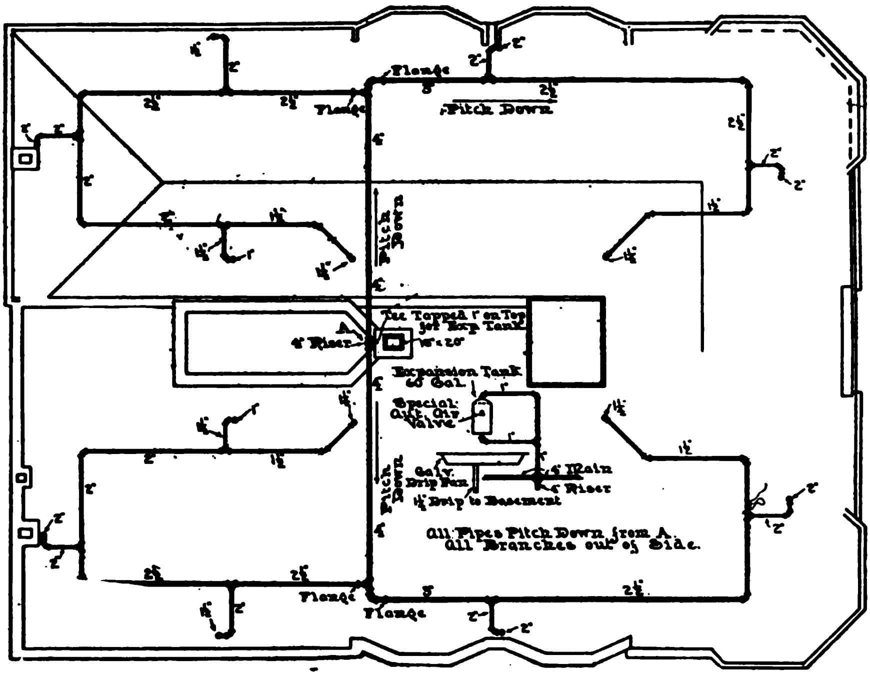

FIG. 21—ATTIC FLOOR PLAN OF APARTMENT BUILDING. CEILING, 7 FT. HIGH

The good features of an overhead hot water heating system are:

First: Lower cost of installation, both in material and labor. In this particular installation the piping is 23.4 per cent. of radiation, while in the ordinary two-pipe hot-water apparatus the piping will run 30 per cent., and in some cases as high as 40 per cent. of the radiation.

Second: Freedom from annoyance of the air valves on the radiators, as all the air in the system vents to the expansion tank in the attic.

Third: Rapid circulation, which causes the water to return to the boiler with less loss of heat than in most other systems and, as a consequence, less fuel is required to run the apparatus.

In this installation there were burned the first winter 48 tons of anthracite coal. Since that they have used from 38 to 42 tons, according to the care and management of the janitor in charge. The average is about one and one-eighth tons per 100 square feet of radiation per season, which is considered a very good showing. The size coal is small egg.

During the early months of autumn and in the late spring, but one boiler is used, and this probably accounts for such good fuel economy.

CHAPTER IX.

TWO PIPE CIRCUIT AND SUBMERGED RETURN FOR WATER HEATING APPARATUS.—BOXING FOR INDIRECT STACKS—AIR FILTERS FOR INDIRECTS.

FIGURES 22, 23 and 24 are floor and basement plans of a modern residence, piped for water heating.

The high point of both lines of pipe are at the boiler, from which they pitch down about one inch in ten feet to the point where they drop to the return, making a continuous circuit from top to bottom of the boiler. By arranging the piping in this manner we have three separate drops to the return of the boiler, thus increasing the motive power which causes circulation.

This is much better than to try to put all the radiation on one circuit, because where that is done, the radiation on the end of the line is always slow in heating.

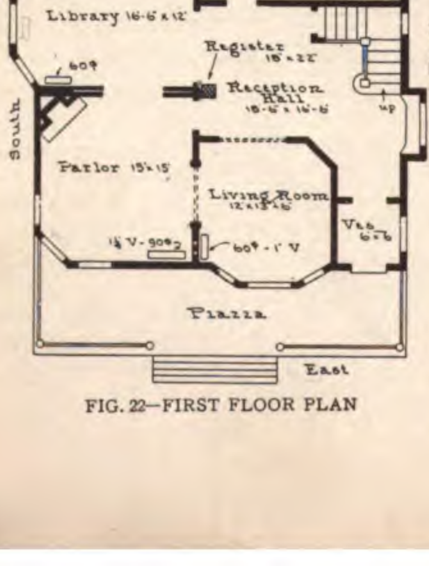

FIG. 22—FIRST FLOOR PLAN

To relieve the mains of air, the two outlets on top of the boiler are connected with ¾-inch pipe from which a line is run to the expansion tank in the attic. All the flow branches are taken off the top of the 3-inch main, except the 1½-inch riser in front of basement, which is taken out of the side to retard the flow and give the first floor radiators time to return. The three returns 1½-inch, 1¼-inch and 1-inch at front of basement are dropped to the lower level of the 3-inch return instead of being connected on the same level as are the flow pipes.

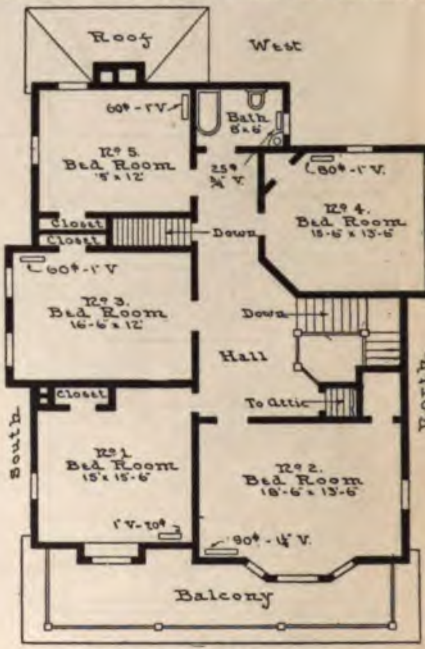

FIG. 23—SECOND FLOOR PLAN

From the 2½-inch main the flow pipes only are connected, all the radiator returns dropping to the main return, which is almost directly under them.

In selecting the boiler, we must allow for 1,500 square feet of direct radiation that the boiler will have to take care of in coldest weather.

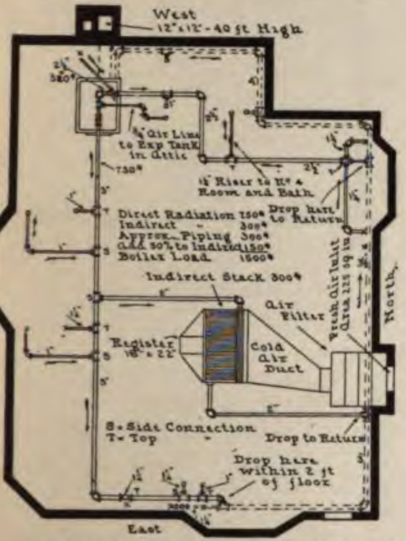

FIG. 24—BASEMENT PLAN, SHOWING THE WATER PIPING

	Sq. Ft.
Of direct radiation there are	750
Of indirect radiation there are	300
Of piping, approximately	300
Additional cooling power of indirect stack	150
Total	1500

For this size job, our preference is for a square, vertical, sectional boiler of following proportions:

Heating surface in boiler	94 sq. ft.
Grate surface	5 sq. ft.
Fuel capacity (anthracite)	350 lbs.
Area of round chimney flue	103 sq. in.
Area of square chimney flue	144 sq. in.

Chimney should be 40 feet in height from boiler grates and the outlet must be above all roofs in the near vicinity to insure a steady draft.

Figure 25 shows details of the indirect installation. Care should be observed in suspending heavy stacks to floor joists, as the floor is liable to sag from the undue weight, causing at times heavy damage. The proper way is to take the weight off the floor joists by using one or more 2-inch pipe columns fitted at each end with floor flanges, with a right and left coupling in center for adjustment, the hangers need not be so heavy when the supporting columns are employed.

Galvanized boxing is preferable to wood lined with tin, and can be done at less cost by metal workers of experience in that line. Fig. 26 shows an excellent way to make the corner seam of galvanized boxing, and Fig. 27 shows a good way to insert the bottom, using ⅛-inch stove bolts. A dust box with hinged bottom should be provided under the register, as shown in sketch. This box should always be of metal, or if made of wood, must be carefully metal lined as matches

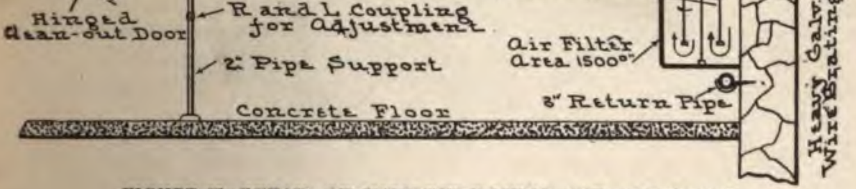

FIGURE 25—DETAIL OF INDIRECT BOXING AND AIR FILTER

may be dropped through the register, and igniting, cause serious damage.

It is bad practice to put the register directly over the stack; of course it is a little cheaper to do so, but very insanitary.

To prevent the dust from a register soiling the adjacent wall, a very small deflector can be used, which need not project over the register more than two inches.

Before the stack is put up, the head lining should be securely fastened to floor joists, and neatly covered with tinned sheets with grooved edges. It seems almost unnecessary to mention this, but the writer has seen large indirect stacks hung within two or three inches of the joists, where an attempt had been made to fasten sheets of tin with carpet tacks over the stack after it was in place. Such work is of the most slovenly character at best, and in a short time, the tacks fall out and the tinned sheets drop on the top of the stack effectually cutting off the air passages.

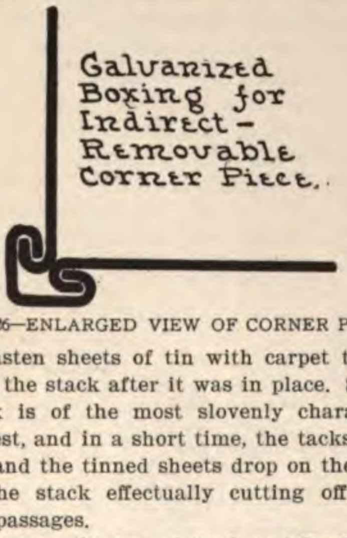

FIG. 26—ENLARGED VIEW OF CORNER PIECE

Between the top of stack and head lining, there should be at least 6 inches of space, and 4 or 5 inches space at the bottom.

A few wood screws used to fasten the tin to the board lining overhead will make a permanent job. The boxing should be fitted to the stack so the air must all pass between the sections. Air will follow the lines of least resistance, and if a space is left between the boxing and the stack, the air will pass into the room without coming in contact with the hot surface of the radiator.

The best way to shut off the air around the bottom of stack is to rivet flanges to the galvanized boxing or tin lining which will press up against the bottom of the stack. See Fig. 28.

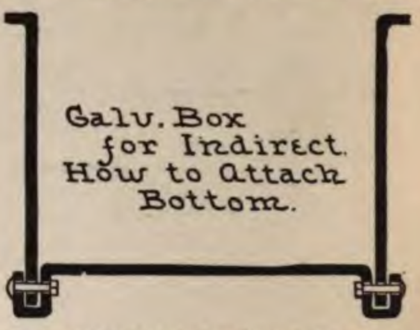

FIG. 27—GALVANIZED BOX FOR INDIRECT

Where the pipes pass through the boxing, fit the opening with split ceiling plates and cement carefully all air inlets.

The air filter shown in Fig. 28 is an inexpensive and excellent device to prevent dust entering the house through the register. The screens are of cheese cloth fastened on removable wood frames placed as shown. A hinged door, the full size of the filter box, permits the removal of the screens for cleaning or renewal.

The area of the cold air inlet should be ¾ of a square inch to 1 square foot of heating surface in the stack, but where the duct is 10 or 15 feet in length, this may be increased to 1 square inch, which latter is the proper proportion for the clear openings in the warm air register. Where the register is too large, the velocity of the rising air will be low and cold

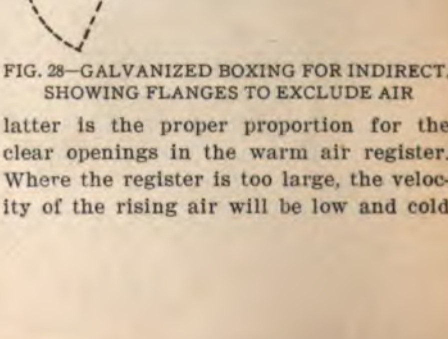

FIG. 28—GALVANIZED BOXING FOR INDIRECT, SHOWING FLANGES TO EXCLUDE AIR

currents of air are likely to drop through some portion of register.

Fig. 29 shows a hot water one-pipe circuit as frequently installed. If a flow pipe be taken off at A and attached to a radiator, and the return be connected at B, the circulation of the circuit will be very feeble. The water in the circuit of pipe circulates because the column D is cooler and consequently heavier than is the column E. Therefore if the return from the first radiator is connected at B the temperature of water in column D will be raised almost as high as that of column E, which of course destroys to a great extent the motive power. In fact such connections have been known to stop entirely the circulation in the circuit.

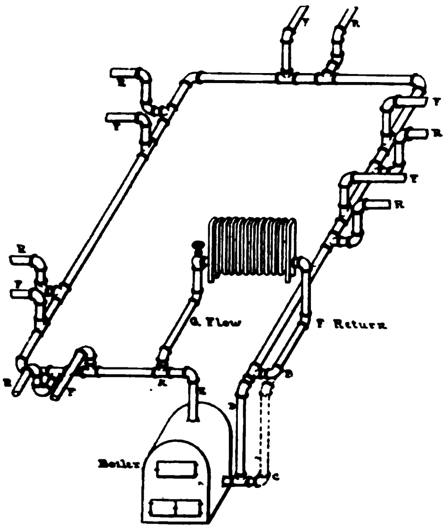

FIG. 29—A HOT WATER ONE-PIPE CIRCUIT

To avoid any such trouble, connect return pipe F to bottom of column D at point marked C, as shown by dotted line.

When a one-pipe circuit is run in this manner, the pipe leading from top of boiler should be first taken around the coldest side of house, so the radiators on that side will get the hottest water. The better way, however, is to run two circuits as shown in Fig. 30, where the returns from both circuits drop to within two feet of basement floor, and return along the wall in one pipe, H. If not convenient to bring the return back along the wall, drop both circuits to floor and return in a trench M, which will make a lift of 18 to 24 inches at boiler. To lighten this lift use the starting pipe N, the use of which is explained on page 56, Fig. 40.

If the circuits are run with the return H, Fig. 30, then circuit K should be on the cold side of the house, as it has only to feed the radiators, the returns dropping to dotted return H while circuit L has to carry the return water as well.

If the amount of radiation be equal on each line the line L should be one or two sizes larger than line K.

Suppose there are 900 square feet on each line, we would run line K 3 inch, line "L" which carries the return water, 4 inch, and the submerged return line, 4½ or 5 inch.

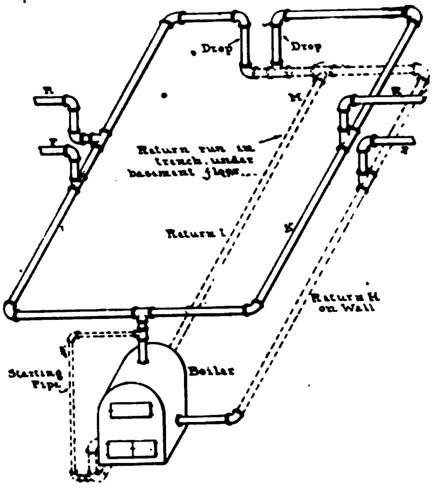

FIG.30—SHOWING TWO CIRCUITS CONNECTED

CHAPTER X.

WATER HEATING APPARATUS WITH INDUCED CIRCULATION—FREAK WATER HEATING APPARATUS—DROP FEED PIPE TO WATER RADIATORS.

A CERTAIN group of green houses were piped for water heating, the circulation to be maintained with a pump from a central water heating plant, but before the pumping plant was completed cold weather set in and something had to be done or all the plants would be ruined. There were about 2,500 square feet of pipe surface in the green houses and the pipes were all much smaller than usual because of the forced circulation to be used. The main flow and return pipe was 3 inches, which will give an idea of the size of the piping, and the distance the water had to travel was 400 feet out and 400 feet back; that is, the green houses were 400 feet long and the pipes entered at the extreme end.

The heating engineer who was consulted had a boiler shed built outside the green houses and ran the pipe from the boiler 30 feet vertically to an expansion tank, thence down to the green house floor and connected there with the 3-inch main which ran along the floor until the various coils were reached, where it rose to the required height. An air pipe was run from the tank one-third the distance from the bottom and carried to the boiler within sight of the operator, where it was equipped with a safety valve.

In fitting the system the safety valve was opened until the entire system was filled with water up to the air pipe. After it was heated the safety valve was again opened and the surplus volume of water, due to expansion, drawn off. This left an air cushion for the air to expand against and the pressure could safely be run up to 20 pounds, above which the valve would open and relieve the pressure. A sketch of this installation is shown in Fig. 31.

In practice the apparatus worked well, better than was expected, as many of the pipes were ¾-inch, but, notwithstanding this apparent handicap the circulation was sufficient all through the buildings to keep them at the desired temperature.

In heating greenhouses with water the main riser should run first to the highest possible point to the expansion tank; from that point pitch down to the coils, as shown in Fig. 32.

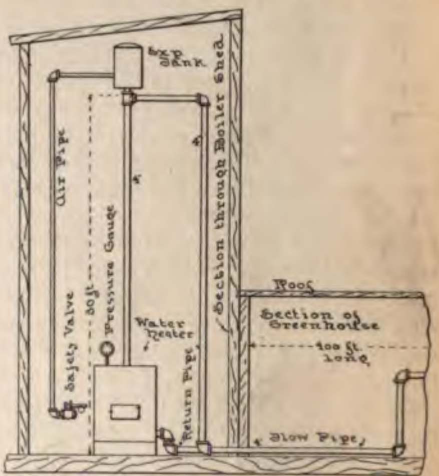

FIG. 31—INSTALLATION OF THE SAFETY VALVE SYSTEM

The idea prevails with some that hot water will circulate only when the mains pitch up from the boiler. This theory is all wrong, for if that were so, how would the water ever get back to the boiler?

Many years ago Chas. Hood stated that in hot water heating the most rapid circulation would be obtained by running the boiler flow to the highest point first

and then dropping to the heating surface, and recent practice proves that Mr. Hood knew what he was talking about.

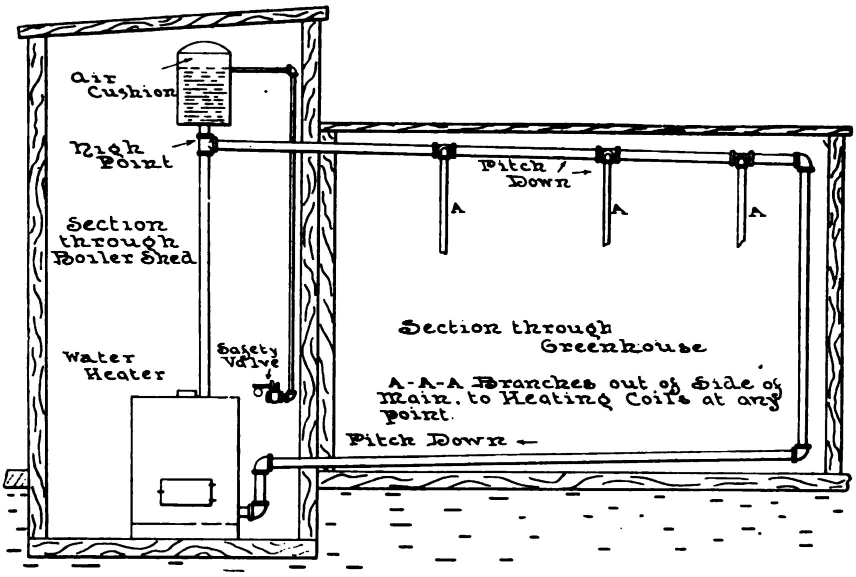
Air Cushion
High Point
Section through Boiler Shed
Water Heater
Safety Valve
Pitch Down
A
A
A
Section through Greenhouse
A-A-A Branches out of Side of Main, to Heating Coils at any point.
Pitch Down

FIG. 32—IN HEATING GREENHOUSES WITH WATER MAIN RISER SHOULD RUN FIRST TO HIGHEST POSSIBLE POINT TO TANK

Another illustration of the value of height to increase circulation is shown in Fig. 33, where the feed for a basement radiator is taken from a riser at the second floor. If there is a third floor radiator convenient that is a still better place to feed from.

An installation which may be classed as a freak is shown in Fig. 34. This represents a store where there is no basement and no place for an expansion tank. In this case the tank is placed on the floor near and connected to the heater near the bottom. When the apparatus is filled with water the air is drawn off the

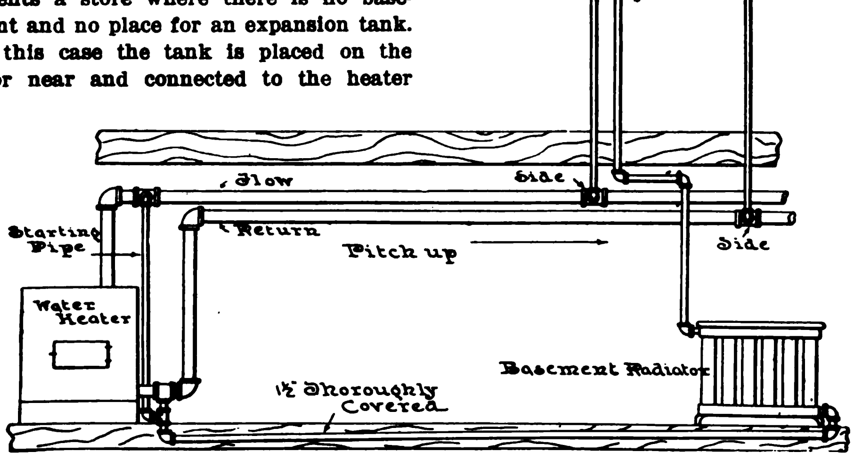

FIG. 33—ANOTHER ILLUSTRATION OF VALUE OF HEIGHT TO INCREASE CIRCULATION

main at the highest point by the air line which is provided with a pet cock to be closed when the air is all extracted. The tank will fill part way with water and compress the air in the top of the tank, which acts as an elastic cushion when the water expands with heat.

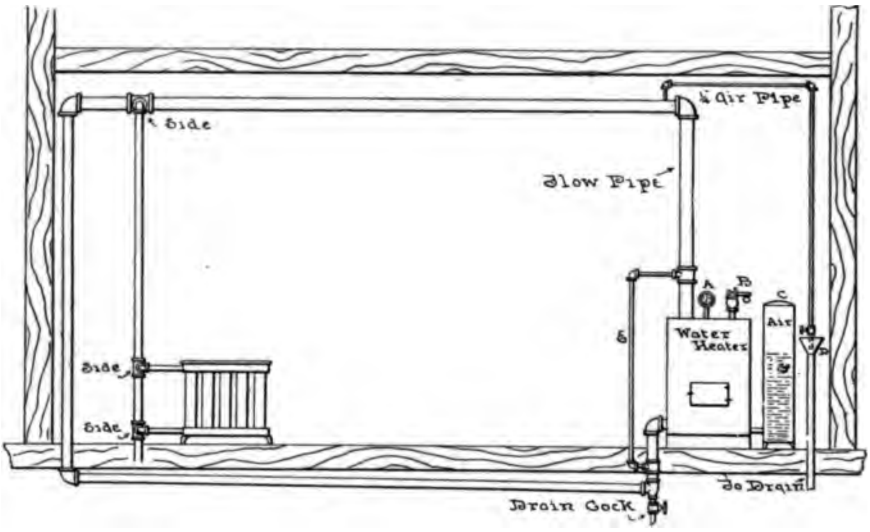

FIG. 34—A, PRESSURE GAUGE; B, SAFETY VALVE PIPED TO FUNNEL D; C. 60 TO 100 GAL. RANGE BOILER; D, FUNNEL TO RECEIVE OVERFLOW OF WATER; E, STARTING PIPE

An apparatus of this kind should only be placed in careful hands, who will look after it and see that the safety valve is kept in good order so that it will operate before the pressure gets excessive. This, however, is a better plan than connecting to the city water mains and using them for an expansion tank. One reason for this is, because when the water gets very hot it will back up into the mains and no cold water can be drawn from the pipes in the neighborhood and another reason is that, in the event of a break and cut off in the city mains, the heating apparatus is left without water and more than likely cracked sections will be the result.

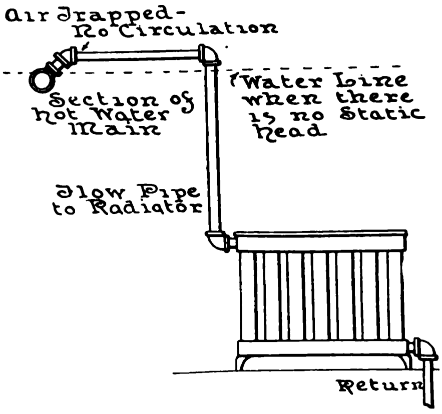

FIG. 35—WRONG WAY TO TAKE FEED PIPE OFF A MAIN TO A HOT WATER RADIATOR

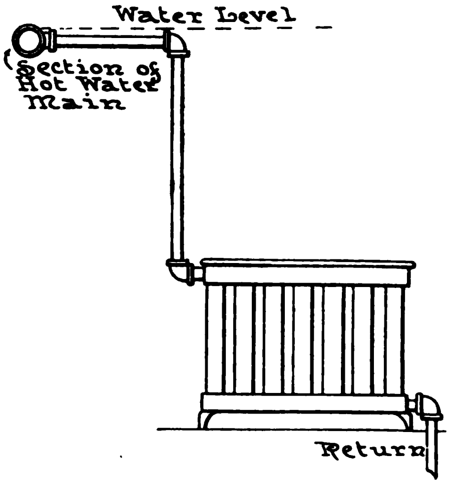

FIG. 36—CORRECT WAY TO TAKE FEED PIPE OFF A MAIN

Fig 35 shows the wrong way to take a feed pipe off a main to a hot water radiator on a lower level. If there are no water lines above the main and connected to same the water will not rise above the line marked "water level." If, however, the pipes extend to a second or third floor above, the static head of the water will compress the air, and if the head is great enough, will make room for a small flow of water in the air trapped pipe. The method, however, is entirely wrong. The branches in such cases must be taken off, as shown in Fig. 36 or Fig. 37. By either of the latter methods the air will vent into the higher levels. In the same way ceiling coils and indirects should be vented into a riser where they are above the main rather than to equip them with air valves, which are likely to be neglected. Many cases have occurred in hot water heating apparatus, where basement coils and direct radiators have frozen and burst because the trapped air would not permit the water in the radiator to circulate and take up heat.

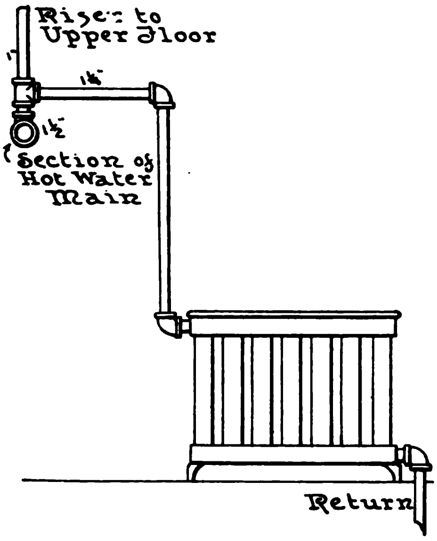

FIG. 37—ANOTHER WAY OF DOING THE WORK CORRECTLY

CHAPTER XI.

HEATING WATER RADIATION ON THE BOILER FLOOR, BY INDUCED CIRCULATION—HEATING A PRINTING OFFICE.

Editor of THE PLUMBERS' TRADE JOURNAL:

ENCLOSED please find a sketch of a hot water job which I have been asked to put in a printing office here, but was afraid it would not work. I wish you would publish in your next issue your views on the subject.

We have a hot blast stove with a 20-inch fire pot and wish to insert a Little Giant heater in same to heat a coil of pipe running around baseboard and return to stove; also a connection running into the two little side rooms to heat a wall coil. The Little Giant heater to be a No. 2 or 3 if necessary.

Now, will the job work as I have it mapped out in the heavy black lines, or will it be better to run it like the dotted lines and change No. 1 to run under floor same as No. 2 does?

Or can it be made to work at all?

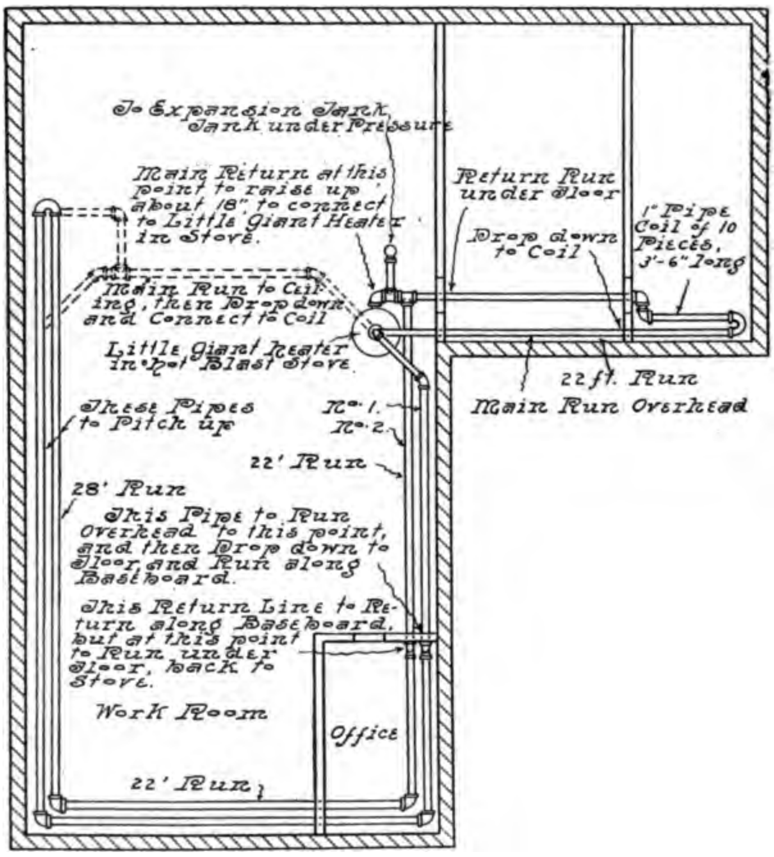
To Expansion Tank, Tank under Pressure
Main Return at this point to raise up about 18" to connect to Little Giant Heater in Stove.
Return Run under Floor
1" Pipe Coil of 10 Pieces, 3'-6" long
Drop down to Coil
Main Run to Ceiling, then Drop down and Connect to Coil
Little Giant Heater in Hot Blast Stove
22 ft. Run
Main Run Overhead
These Pipes to Pitch up
No. 1.
No. 2.
22' Run
28' Run
This Pipe to Run Overhead to this point, and then Drop down to Floor and Run along Baseboard.
This Return Line to Return along Baseboard, but at this point to Run under Floor, back to Stove.
Work Room
Office
22' Run

FIG. 38—INSTALLING A HOT WATER SYSTEM—J. F. M'S PLAN OF THE HEATING JOB

The whole job to be run under pressure. And what size pipes will I have to use on the long coil around baseboard if it can be made to work?

The first essential is to know the quantity of pipe coil necessary to heat the space in question. As the plans do not show the size or exposure, we will, to make the matter plain, assume that in the room to be heated there are 120 square feet of exposed glass; 800 square feet of exposed wall, and 10,000 cubic feet of space; the air in the space to be changed once per hour, which will conform to normal conditions.

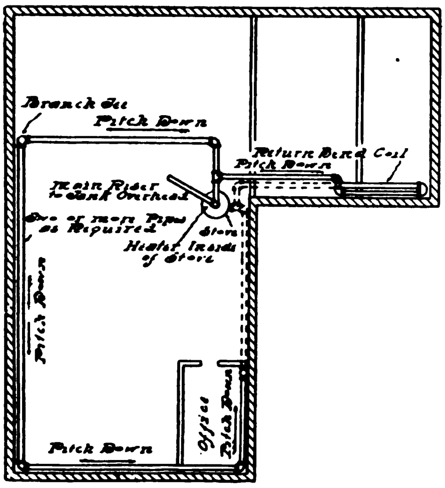

FIG. 39—FLOOR PLAN OF JOB. OUR SKETCH

As it is proposed to run the job under pressure, we will assume that with a strong fire the piping will be at a mean temperature of not less than 200 degrees. Under these conditions we will assume that each square foot of pipe will emit 200 British thermal units per hour. We will first find out how much heat we are going to lose per hour in British thermal units, and this we go about in the following manner:

Square feet of exposed glass...	120x72= 8,640
Square feet of exposed wall....	800x22=17,600
Cubic feet of air..........	10,000x1.4=14,000
Total loss of heat per hour in B. T. U.'s.	40,240

This, divided by 200, shows that 200 square feet of pipe is required to heat a room whose cubic contents and cooling surface is as described above.

This method of obtaining the proper amount of radiation is fully described in chapters two and three under the heading Heat Transmission. In that article we assume a lower temperature in the radiators, and as a consequence a lower emission of heat, and, instead of 200 we use 150. That, however, is for low temperature open tanks.

In this case we have a closed system, and with a heater of the proper size and active combustion, we would be able to maintain a steam temperature in the pipes. The efficiency of the heater which is to be placed in the stove will depend almost entirely upon its position. The quantity of radiation it will heat will also depend upon the activity of the fire. The writer has known small heaters of this nature that were capable of taking care of 60 square feet of radiation, and on the other hand they have been so placed that they would not take care of more than 10 feet.

We think it would be safe to figure in this particular case that 1 square foot of the heater will take care of 30 square feet of radiation and piping, which would require for 200 feet of radiation, 6½ square feet of heating surface in the heater. Probably the manufacturers of this heater can throw some light on the subject, but it must be remembered that where the manufacturer states that 1 square foot of his heater will take care of 30 or 40 square feet of hot water radiation, the statement amounts to nothing unless the temperature of the radiators is stated, as well as other conditions.

It would be folly to install this apparatus without first of all determining the quantity of pipe coils necessary to heat the building, and then it would be folly to put in a closed tank system unless the heater is of sufficient size to heat the water above the ordinary boiling point.

Had our correspondent sent us the size of the rooms, the square feet of glass and the square feet of exposed wall, together with the required temperatures, we would have been able to give him a much more intelligent answer to his questions.

Turning to sketch No. 39, we have prepared a floor plan, following as nearly as possible the contour of our correspondent's sketch. The pipe from the heater rises directly to the ceiling, where it is connected to the expansion tank. Immediately below the expansion tank is placed a cross, and from each side of the cross is taken out a branch line, which pitches down to the respective coils. The tank is the highest point and will relieve the system of all the air. We do not like the idea, as suggested in our correspondent's letter, of carrying the water through a long pipe coil and returning it in the same manner. It is much better to make the coil as shown in sketch No. 41, which is an interior view of a room showing a two-branch pipe coil on the wall connected to branch tees. This interior sketch also shows the main riser to the tank and one branch feeding the two-branch wall coil. It also shows the proper method of running the overflow pipe from the expansion tank, and the placing of the safety valve down by the boiler where it is accessible.

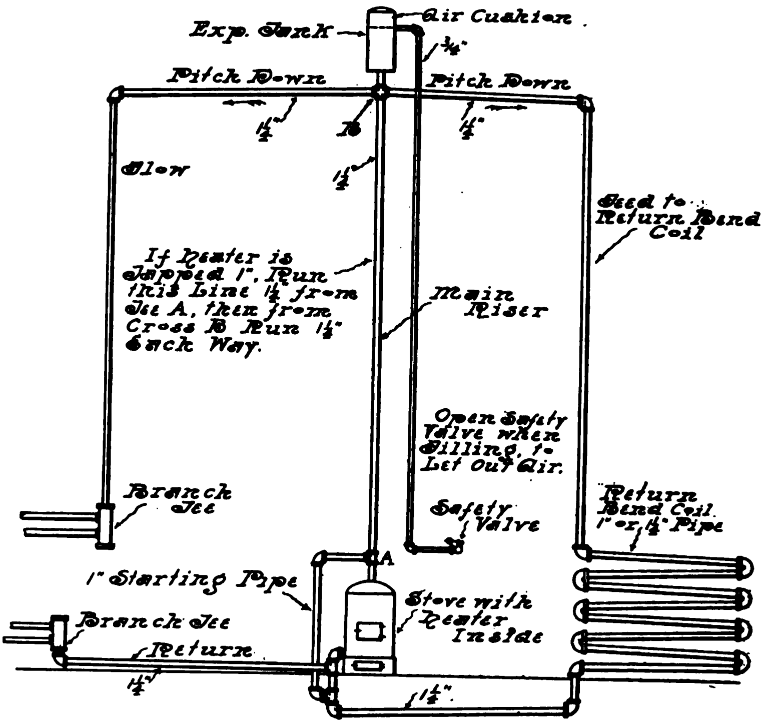

FIG. 40—SECTIONAL VIEW OF HEATING APPARATUS TO BE INSTALLED IN PRINTING OFFICE

A better idea may, perhaps, be obtained by sketch No. 40, wherein is shown a section of the apparatus.

Here we show the stove with heater inside. From the top of the heater is taken a 1¼-inch pipe to the expansion tank. From either side of this pipe, just below the tank, are taken two 1¼ branches, one of which feeds the two-pipe coil, the other the return bend coil. The return from the branch tee coil is shown above the floor, the return bend coil is shown below the floor, and both of these being connected into one pipe rise and are connected to the heater. This rise being from 18 to 24 inches in height, and being the coldest part of the water will naturally retard the circulation, and to assist this we show what is called a starting pipe taken from the flow pipe where it leaves the stove, and dropped back to the lower part of the rising part of the return. The device lightens the water in the lift of the return, and permits of much easier and more rapid flow of water than could otherwise be obtained.

It will be noticed that the ¾ overflow is taken from a point about two-thirds from the bottom of the expansion tank, the other third being an air cushion. This will permit the water to be superheated, which will compress the air, and when this pressure rises above the point at which the safety valve is set the apparatus will be relieved.

It will not be necessary to use the starting pipe if the main returns can be carried above the floor and on a level with the return of the heater, but we scarcely think this would be practicable, and we have shown the starting pipe device.

The explanation in regard to determining the quantity of radiation required will answer our correspondent's question regarding the proper size of pipe to use. If he finds that 200 feet are necessary to heat the building, he must then decide the length of his coils, and that will determine the size and number of pipes. For example: If the return bend coil made of 1-inch pipe contains 40 square feet, and the exposed mains contain 20 feet more, there will still be 140 feet to provide, and if it is convenient to run but two pipes on the wall, he may have to use 2-inch pipe in order to get in the surface. For one square foot of heating surface there will be required 3 square feet of 1-inch pipe, 2.3 square feet of 1¼-inch pipe, 2 square feet of 1½-inch pipe and 1.6 square feet of 2-inch pipe. With this data, necessary quantities can easily be determined.

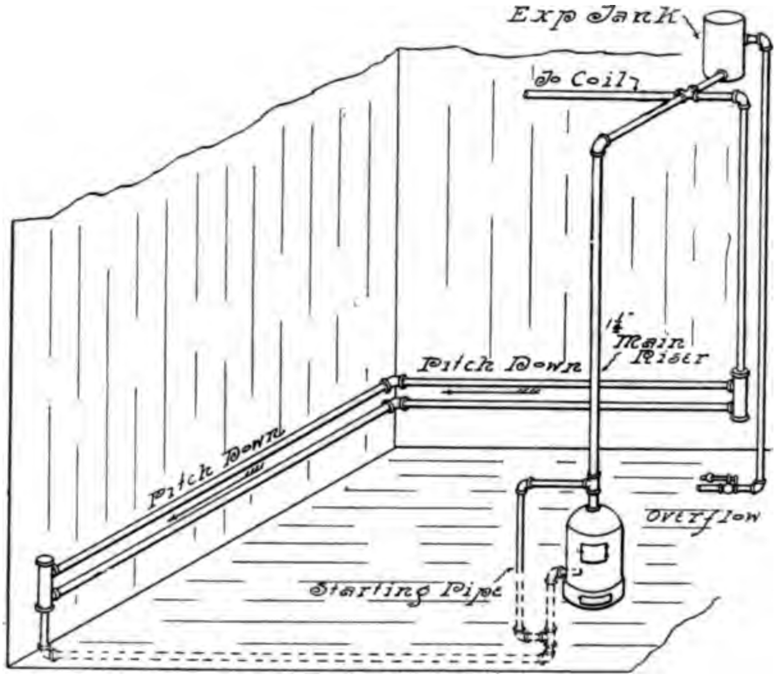

FIG. 41—SHOWING INTERIOR VIEW OF ROOM WITH BRANCH TEE COIL ON TWO SIDES OF ROOM

CHAPTER XII.

DOMESTIC VACUUM HEATING.

THE heating contractor who advocates water heating only for residence work will lose many jobs that he might have secured had he advocated and figured on a good steam heating apparatus, because the latter costs so much less than does water heating.

It may be well to explain that these articles on heating are written from the heating contractor's standpoint, and some of the pipe sizes and rules given for certain work will not be in accord with some of the text books. For example: The text books say that in hot water heating the area of the flow main should equal the combined area of all the branches and that the tappings furnished by the radiator manufacturers will serve as a guide to the size of the mains. All very good. Such jobs will work, of course, though they are sometimes waterlogged, and the boiler has all it can do to heat the water in the mains to say nothing of the water in the radiation, but the man who figures work according to that rule against a man who knows how to proportion his piping, will do nothing but figure, while the other fellow will do the work.

Take a 2,000 square foot water heating job, with thirty radiators tapped 1¼ inch and 10 radiators tapped 1½ inch. The combined area of all the radiator tappings (branches same size as tappings) is 54½ square inches; the area of an 8-inch pipe is 50 square inches, and this you must use if you follow instructions—or you could use one 5-inch and one 6-inch, or four 4-inch, but your competitor, if he knew his business, would use one 5-inch or possibly one 4-inch main and would not use one 1½-inch valve on the job and few 1¼-inch.

A prejudice exists among many people regarding the use of steam in the house. They say that it overheats, that you get a temperature in the rooms of 212 degrees or nothing, and a range of only 15 degrees—from 212 to 227 (5 pounds).

This is not strictly true. Water boils at 212 degrees at atmospheric pressure, at sea level, but it emits a hot vapor at 180 degrees, and in all well planned and well executed heating plants this vapor will circulate a short distance, which gives a range of temperature from 180 degrees to 227 degrees (5 pounds steam) or 47 degrees range of temperature, and if we relieve the radiation of a portion of the atmospheric pressure, we can get the water to boil and throw off a vapor as low as 125 degrees in practice, which gives a range of temperature of from 125 degrees (25 inches vacuum) to 227 degrees (5 pounds pressure) or practically 100 degrees range of temperature.

FIG. 42

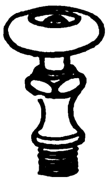
FIG. 43

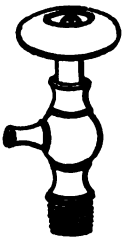
FIG. 44

To illustrate: Suppose we install a steam plant in a residence; get up steam and fill all the radiation with steam. As the steam enters the radiator, being lighter than air, it rises to the top of the loops and with the pressure from the boiler, expels all the air from the radiator. If there is an automatic air valve on the radiator, it will close when the steam reaches it and the radiator will be filled with steam in place of air. The steam which is condensed by the radiator is replaced by fresh steam from the boiler so long as there is sufficient fire to evaporate the water.

When the fire gets low the radiator will condense the steam faster than the boiler can supply it and the air enters through the automatic valve to fill the space which the steam had occupied before condensation.

Now, suppose each and every radiator had been furnished with a positive air valve operated by hand and tightly closed when the radiators were all filled with steam. Now, when the fire gets low the radiators remain warm, but at a lower temperature, and will continue to emit heat but at a constantly decreasing temperature so long as no air enters the system, until the temperature of the water in the boiler drops down to 100 degrees. This is domestic vacuum steam heating.

Now, if instead of positive air valves, we use automatic air valves, so arranged that they will allow the air to escape but will not permit it to enter the radiator, we have an automatic vacuum system and can get all the advantages of water heating at a greatly decreased cost.

It is, of course, necessary to have the piping tight and vacuum valves on all the radiators because wherever the air enters the system it will kill the existing vacuum throughout the entire apparatus.

We illustrate a few of the different kinds of valves now in common use.

Figs. 42, 43 and 44 are positive steam air valves. Figs. 45 and 46 are hot water air valves. Fig. 47 is one of the simplest forms of automatic steam air valves. It is closed by the expansion of a vulcanized post from the heat of the steam. This valve is provided with a thread to which can be attached a ⅛-in air line carried to the basement to prevent any dripping of water.

Fig. 48 is the form of air valve usually employed to put on the return end of a steam main to relieve it of air. Fig. 49 is a simple form of vacuum automatic air valve. The ball shown in the base of the valve is there to prevent air from entering the radiator as the steam pressure relaxes. These vacuum valves are made at present in other ways than shown in the illustration.

Fig. 50 is an automatic air valve with a float, the latter to prevent water from escaping when there is not sufficient heat to close the valve by the expansion of the post. Fig. 51 is an automatic float valve with a small syphon tube inserted in connecting end, which drops into the loop of the radiator and is said to have the effect of clearing the radiator air valve of the water of condensation more freely than when it is not employed.

The principle of vacuum heating is, of course, based on the fact that water boils at 212 degrees Fahrenheit at sea level where the atmosphere exerts a pressure per square inch of 14.7 pounds. This is called absolute pressure.

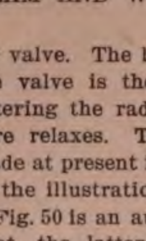
FIG. 45

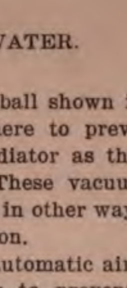
FIG. 46

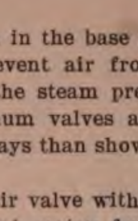
FIG. 47

When water is heated in a sealed apparatus, such as a steam plant, the pressure will soon rise in the apparatus above the atmosphere, which is indicated by the steam gauge and this is called gauge pressure.

When the gauge shows 5 pounds we say there is 5 pounds pressure at the boiler, but there is really 5 pounds, plus the pressure of the atmosphere—14.7—making 19.7 pounds pressure. We will start at the atmospheric pressure of 14.7 at which point the steam is leaving the boiler at a temperature of 212 degrees. We check the fire so the boiler will not supply the steam at that temperature as fast as the radiators will condense it, but if the air is prevented from taking the place of the condensed steam, the water will continue to boil and throw off vapor, the temperature of which is below 212 degrees, because the atmospheric pressure on the water in the boiler has been reduced by the action of the condensing steam.

The following table shows the temperatures at different absolute pressures, with the corresponding readings of the pressure and vacuum gages:

Absolute Pressure Lbs. per Sq. Inch.	Gauge Pressure Lbs. per Sq. Inch.	Vacuum Gauge Inches of Mercury.	Temperature of the Steam FHT.
25	10.3		240.0
24	9.3		237.8
23	8.3		235.4
22	7.3		233.
21	6.3		230.5
20	5.3		227.9
19	4.3		225.2
18	3.3		222.4
17	2.3		219.4
16	1.3		216.3
15	0.304		213.0
13.0		3.45	205.9
14.7 atmos.	0.00		212.0
14.0		1.41	209.6
12.0		5.49	202.0
11.0		7.52	197.8
10.0		9.56	193.2
9.0		11.60	188.3
8.0		13.63	182.9
7.0		15.67	176.9
6.0		17.70	170.1
5.0		19.74	162.3
4.0		21.78	153.1
3.0		23.83	141.6
2.0		25.85	126.3
1.0		27.88	102.1

As it is practicable in the system described, to get 25 inches on the vacuum gage, a glance at the table will show the increased range of temperature over the ordinary steam heating plant.

The proper gage to use is a combination which shows the vacuum in inches on one side and pressure above atmosphere on the other.

We have seen that at the sea level the pressure of the atmosphere is 14.7 pounds per square inch, so it follows that at points above sea level the pressure will be less. Starting at sea level, we have a pressure of 14.7 pounds, at which pressure water boils at a temperature of 212 deg. F. At ¼ mile above sea level the pressure is 14.02 pounds; at ½ mile, 13.33; at ¾ mile, 12.66; at 1 mile, 12.02, at which altitude water boils at a temperature of 200 deg. F.

Denver, Col., is located just one mile above sea level, and a steam heating plant in that city, operated at atmospheric pressure, will give off its vapor at 202 deg., or 10 degrees lower temperature than is obtainable in localities near the coast. Five hundred feet altitude decreases the boiling point of water about one degree F.

In New York City are some of the finest living apartments that money can build and furnish, and they are all, or nearly all, steam heated and without any arrangement to heat below atmospheric pressure. It may be said that many of the jobs are not wholly satisfactory, and the same might be said of water heating, without detracting from the value of either system.

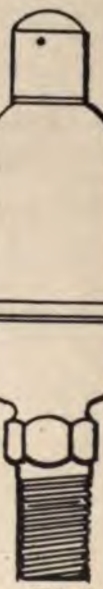
FIG. 48

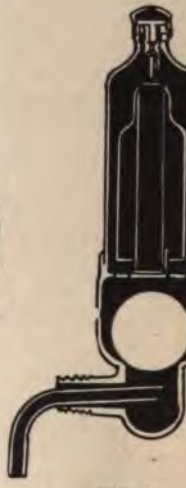
FIG. 49

In the matter of fuel economy, there will be no difference between water heating and vacuum steam heating, if both are equally well installed.

In old houses where no provision has been made for risers or radiators, the steam plant can be much more readily adapted to conditions and much less cutting of floors is required. In new buildings, where temporary heat is required, the steam radiator can be permanently connected, swung out from the wall, and swung back when floors and walls are finished, but the water radiator must be connected twice.

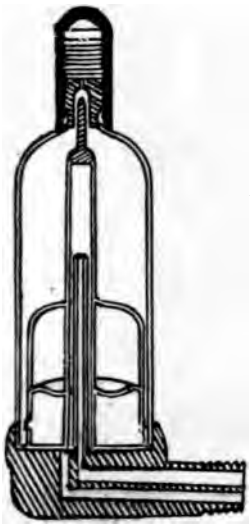

FIG. 50

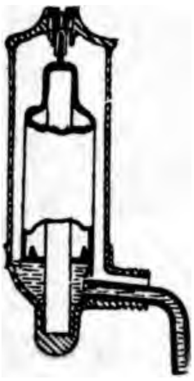

FIG. 51

COMPARATIVE COST OF A WATER AND VACUUM STEAM HEATING JOB.

Steam.

600 square feet radiation at 20c	$120.00
900 square feet boiler	175.00
Pipe and fittings—7 per cent. of radiation	42.00
Radiator valves (12 at $1.50)	18.00
Vacuum valves	12.00
Decorating radiators, 2c. foot	12.00
10 days labor at $6.00	60.00
Pipe covering—5 per cent. rad	30.00
Cartage, etc.	10.00
	$479.00
Add 20 per cent	95.00
Bid	$574.00

Water.

For same house—60 per cent. more radiation.

960 square feet radiation at 20½c	$196.00
1500 feet boiler	165.00
Pipe and fittings—10 per cent. of radiation	96.00
Radiator valve air cocks at $1.50.	18.00
Expansion tank	10.00
Thermometer at alternating gage.	3.00
Decorating—2c. foot	19.00
18 days labor at $6.00	108.00
Cartage, etc.	12.00
Covering—5 per cent. radiation	48.00
	$676.00
Add 20 per cent	135.00
Bid	$811.00

These figures show a difference of $237.00 in favor of the steam plant, and if the latter is properly installed, it will be fully as satisfactory as the best water heating job, and besides, the owner can well afford to pay $25.00 to $35.00 extra for an indirect stack for ventilation, which will then place it far ahead of the water system.

CHAPTER XIII.

HEATING A MERCHANDISE STORE.

THE accompanying floor plans represent a three-story building used for a retail store. The first and second floors may be devoted to sales rooms and the third floor to a millinery or sewing room.

The first story is protected on both sides by other buildings one story high. Both of these adjoining buildings are warmed, and consequently the side walls of the first floor of the three-story building will not lose any heat. Neither will there be any loss of heat through the ceiling so long as the second story rooms are at the same temperature as the first story.

The second and third stories are exposed on all sides. The walls are brick, 12 inches thick, and the roof is an ordinary tar and gravel flat roof with an air space of an average of 12 inches between the ceiling and the roof.

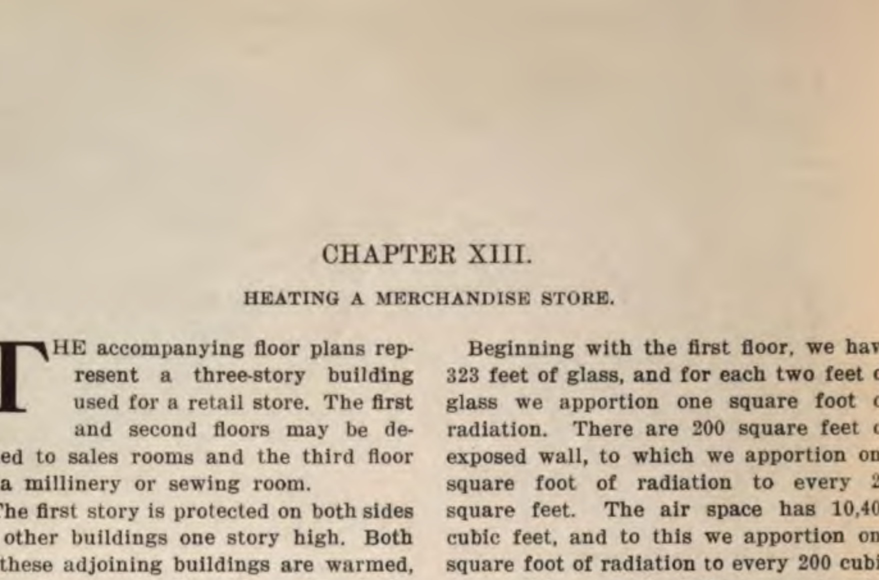

FIG. 52—BASEMENT PLANS TO REPRESENT A THREE-STORY BUILDING

Beginning with the first floor, we have 323 feet of glass, and for each two feet of glass we apportion one square foot of radiation. There are 200 square feet of exposed wall, to which we apportion one square foot of radiation to every 20 square feet. The air space has 10,400 cubic feet, and to this we apportion one square foot of radiation to every 200 cubic feet, making a total of 224 square feet for the first story.

The second floor is figured in the same manner, and there being more glass and more exposed wall, the total radiation is 269 feet.

On the third floor, in addition to the glass and walls, we have a loss of heat through the roof, and as it is never possible to know exactly the rate of cooling through a roof where there is an air space, it is best to treat it in the same manner as the brick walls. If the air space between the ceiling and roof were perfectly tight, there would be almost no loss of heat as quiet air is an excellent non-conductor.

The building is to be warmed by a low pressure steam heating apparatus not to exceed five pounds gauge pressure at the boiler. There are two rooms in the front part of the basement, each of which will require, in addition to the steam mains, 30 square feet of radiation. It is imperative that these radiators stand on the floor level, and if they are to be heated by steam, the only alternative is to set the boiler in a pit so the radiators will stand above the water line, but as this scheme is not practicable in this case, and as the owner will not allow the boiler to be tapped for hot water pipes below the water line, the only resource is to use hot water radiators and heat them by the water of condensation.

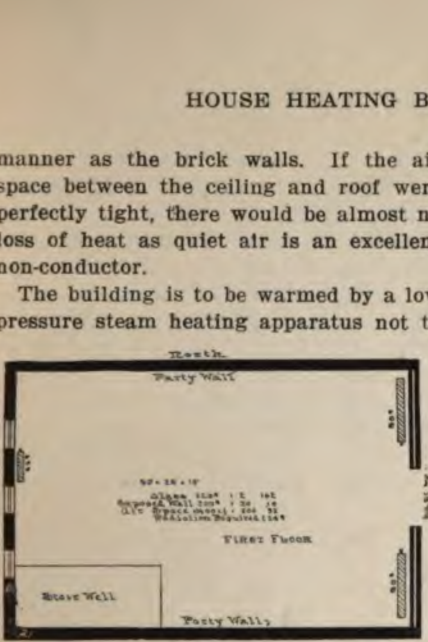

FIGURE 53

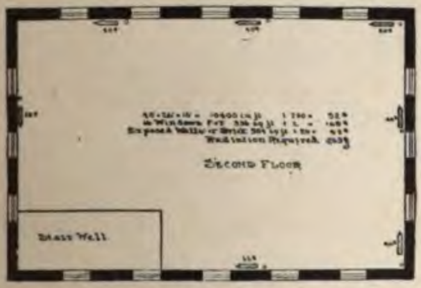

FIGURE 54

As the circulation through these radiators will be somewhat slow, depending entirely upon the amount of condensation, we estimate there will be required 50 feet in each radiator to make up for the difference in temperature between that of steam and water, as the water radiators in this particular installation will not average above 150 degrees temperature.

In figure 57 is shown the proper method for connecting these hot water radiators. The radiator shown in Fig. 70 is marked E in the basement plan, and the object is to divide, as evenly as possible, the condensation between the two radiators.

Referring to Fig. 52, which is the basement plan, we run the 3-inch main from the boiler until we reach the radiator marked F. At this point we put on a tee 2½ x 1½ x 3 inches. The 1½-inch is connected with the top of the radiator, while the 2½-inch rises for the continuation of the 2½-inch steam main. This 2½-inch main extends to the radiator marked E, and at this point is used a tee 2 x 1½ x 2½ inches. The 1½-inch is connected with the top of the radiator in the same manner as just described, and the main again rises and is continued 2 inches to the furthest riser, marked H. From the risers H and G is carried a return which connects into the feed of the radiator E. below the water line of the boiler.

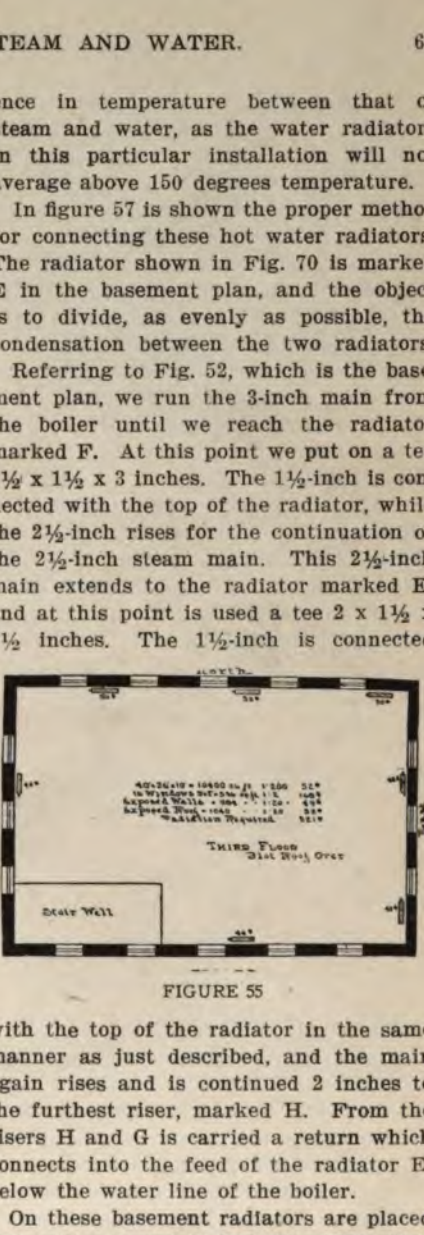

FIGURE 55

On these basement radiators are placed two valves, A and B, Fig. 57. When it is desired to have the radiators warmed, the valve B is closed and valve A is opened, but when the radiator is closed off, B must be opened to allow the water of condensation to return to the boiler. The return pipe is shown in this case under the floor, but is frequently run on top of the floor, next to the wall, all depending upon conditions.

In Fig. 56 is shown a section of the

building in elevation, and three different methods of connecting risers. The first method, shown in riser A, cannot be too strongly condemned, as there is no provision made for the expansion of the pipe. It is true that in a three-story building the expansion of the risers is very slight, but it is also true that in many cases the connections to the radiators are made very small and rigid so that a slight lengthening of the riser will tip the radiator out of position, causing a small quantity of water to lie in the bottom, which will be a source of annoyance from water hammer, as many have experienced.

In riser B the radiator connections are shown taken off above the floor, carried back of the radiator and connected to same by a corner valve. In this arrangement, with only two stories for the riser to pass through, there is no need of making provision for expansion if the branches to the radiators are given a generous pitch.

In riser C we show the arms taken off beneath the floors and in D the riser is shown hung at the second floor. The detail of this manner of hanging risers is shown in Fig. 59. The riser is cut to such length that a plain coupling connects the riser to the third floor, and this coupling rests upon a one-piece, cast-iron floor plate on second floor. Any expansion that takes place in the riser will be divided at this point, one-half of the expansion going upward and the other half downward. The ceiling plates should, if possible, be fastened to the sleeve, which passes through the floor. This is not the common practice, but it is the best. When the ceiling plate is fastened to the riser and set up close to the plastering, the expansion of the pipe will, in time, break the plastering, providing the floor plate is screwed tightly to the riser, and if it is not tight, it will soon work loose.

In Fig. 58 we show two riser connections, A and B. In riser B the connection leaving the main is supposed to be short and rigid. The branch to the radiator, which is under the floor, is supposed to have been placed on a level with right angle elbows. Under these conditions the expansion of the riser will push it up and

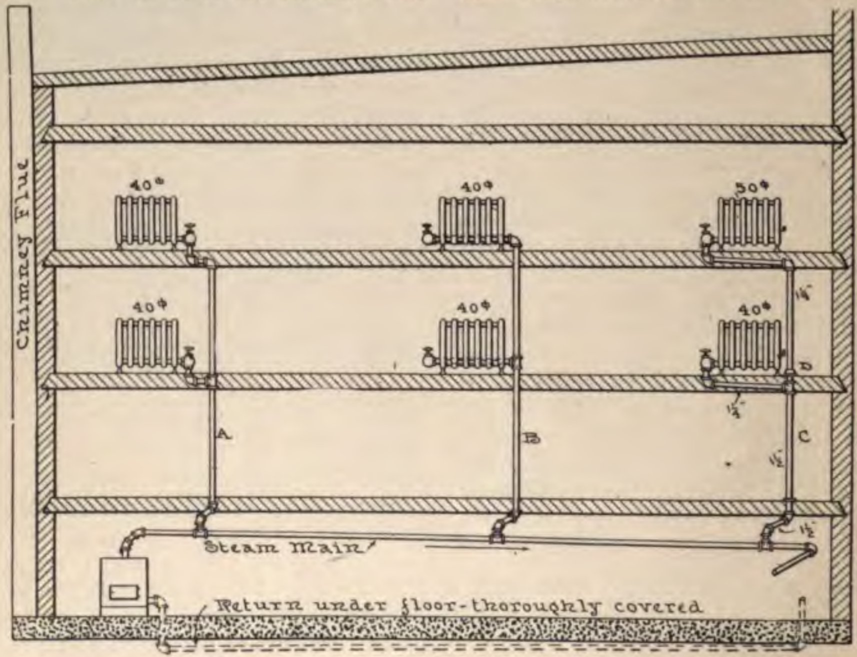

FIG. 56—SECTION OF BUILDING IN ELEVATION AND THREE DIFFERENT METHODS OF CONNECTING RISERS

form a small trap, as shown by the dotted line, which will contain enough water to be noisy. At A the riser is shown taken off the side of the main and pitched up at a sharp angle. Between the outer end of the arm from the main and the riser are two elbows, which permit the riser to set perpendicular. The detail of this connection is clearly shown in Fig. 60.

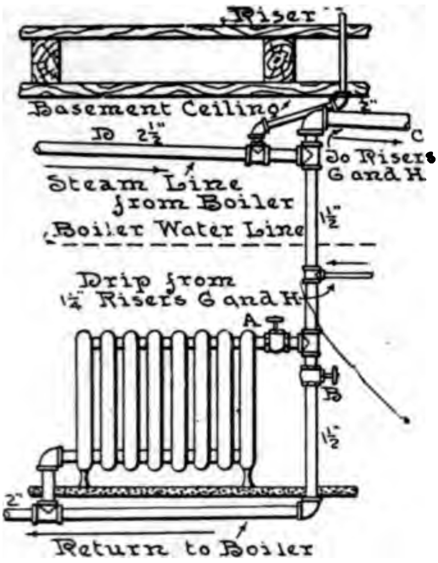

FIGURE 57

The advantage of using two elbows at the foot of the riser is that it gives the opportunity for a sharp pitch uward of the arm leaving the steam main. If an arm is taken off a main with an elbow at any angle, and an elbow placed on the outer end. a crooked thread must be cut on the bottom of the riser to make it stand perpendicular, unless "pitch" elbows are used, and as these elbows are sometimes confusing, getting mixed among the other fittings, the steam fitter, as a rule, avoids them, although they are the proper fitting to use to obtain the best results in steam heating.

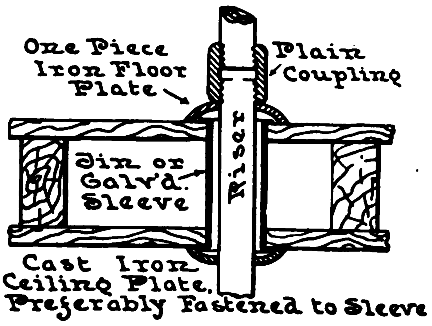

FIGURE 58

There art 914 square feet of radiation, to which we will add for the piping 182 square feet, or 20 per cent. of the figured radiation, and call the boiler load 1,100 square feet. If the fuel is to be hard coal, and heat must be maintained for eight hours without attention, we will require a boiler with 4.9 square feet of grate, 65 square feet of heating surface and a fuel capacity of 390 pounds. If the heat is to be kept up for ten hours, a larger boiler will be required to obtain a fuel capacity of 485 pounds. This assumes that all the radiation is to be kept at a temperature of 220 degrees Fahrenheit for eight or ten hours without attention to the fire, and that the air in the rooms where the radiation is placed shall be maintained at 70 degrees Fahrenheit.

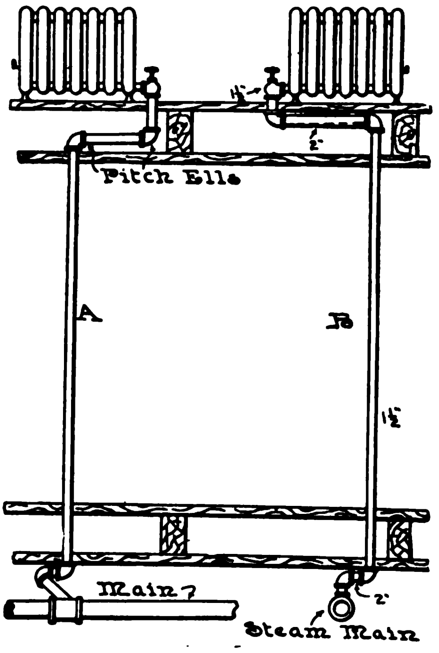

FIGURE 59

If it is necessary to keep only about

half of the radiation in commission during the night, the first mentioned boiler will be sufficiently large to carry fire for ten or twelve hours.

In designating the fuel capacities, we assume the most trying weather conditions, which may not occur more than three of four times during the season; but if the boiler has a fuel capacity for only six hours and if, during a night of severe frost, the water pipes freeze and burst, there might be enough damage done to the building and contents to pay for several boilers.

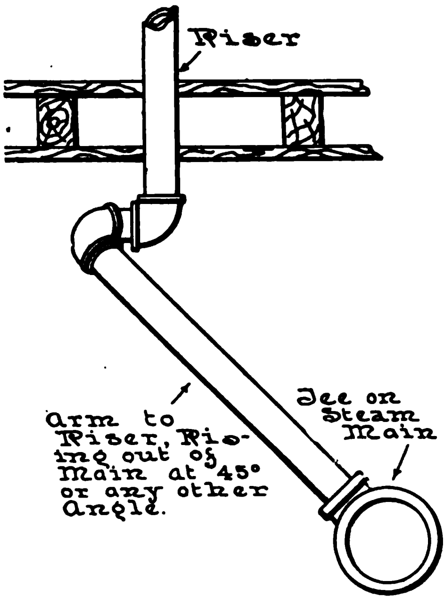

FIGURE 60

If soft coal is to be used, select a square boiler with a large fuel chamber and extra large gas passages. The fuel capacity should be just about 50 per cent. greater than for hard coal, if heat is to be maintained the same length of time.

The chimney flue for this installation should be not less than 40 feet in height from the boiler grates to the top, and should be, if square, 12 x 12 inches inside, and if round 12 inches inside diameter.

It will be noted that this store is heated by the rule in common use of 2-20-200, which gives to the first floor 224 square feet of radiation, to the second floor 269, and to the third floor 321 square feet. In chapter 2 it is shown that by the laws of heat transmission the rule for glass should be 1 to 3 instead of 1 to 2, and the rule for wall should be 1 to 12 instead of 1 to 20. The rule of 2-20-200 will hold good where the proportions of wall and glass do not vary greatly, but where there is a preponderance of glass and a small quantity of wall, the rule gives too much radiation.

A more exact rule for figuring store buildings, such as is shown in this article, is to divide the exposed glass by 3, the exposed wall by 12, and the cubic contents by 200, where it is supposed there will be a change of air once per hour. This latter rule would give to the first floor 177 square feet, to the second floor 246 square feet, and to the third floor 333 square feet. This gives only 58 feet less than the rule by which the building is figured, but the distribution of the heat is different, there being a less amount of radiation on the first and second floors and a greater amount on the third floor. In detached store buildings the walls which are shelved and filled wtih goods, may be disregarded as cooling surface.

CHAPTER XIV.

PLANS OF A SUCCESSFUL WATER HEATING APPARATUS—DIRECT RADIATION.

IT may be of interest to look over some plans and data of residences which have been successfully heated. Fig. 61 is the basement plan, Fig. 62 the first floor and Fig. 63 the third floor of a residence heated with hot water direct radiation and the single pipe circuit system of piping in the basement.

This work was installed in 1893, and has been satisfactory in every respect, the owner saying that there is nothing about the heating apparatus that he would care to have changed.

The house is near one of the great lakes, exposed to all the winds that blow. It is well built, however, and in placing the radiation care was taken to have enough to insure a temperature of 72 degrees in all the rooms, with the water in the radiators at 160 degrees when the external temperature was at zero, and there has been no difficulty in carrying out these conditions.

Figuring from the cubic contents only, the radiation in the rooms on the first floor will show about one square foot of radiation to 24 cubic feet of air space. The second floor is figured in the same manner. The radiators, with the exception of one in the den and one in the servants' dining-room, are of standard height, three-column, containing five square feet to the loop. The direct cast iron radiators figure up 1,097 square feet. The pipe coil in the laundry has 23 square feet, and the piping will add 336 feet, making 1,456 feet for the boiler load.

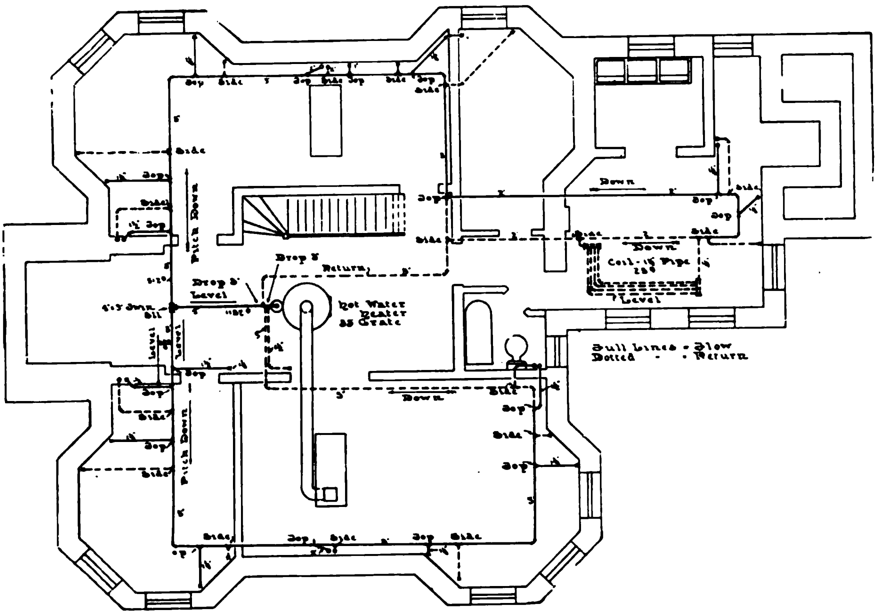

FIG. 61—RESIDENCE. BASEMENT PLAN INSTALLED 1S93.

The boiler used was a round sectional

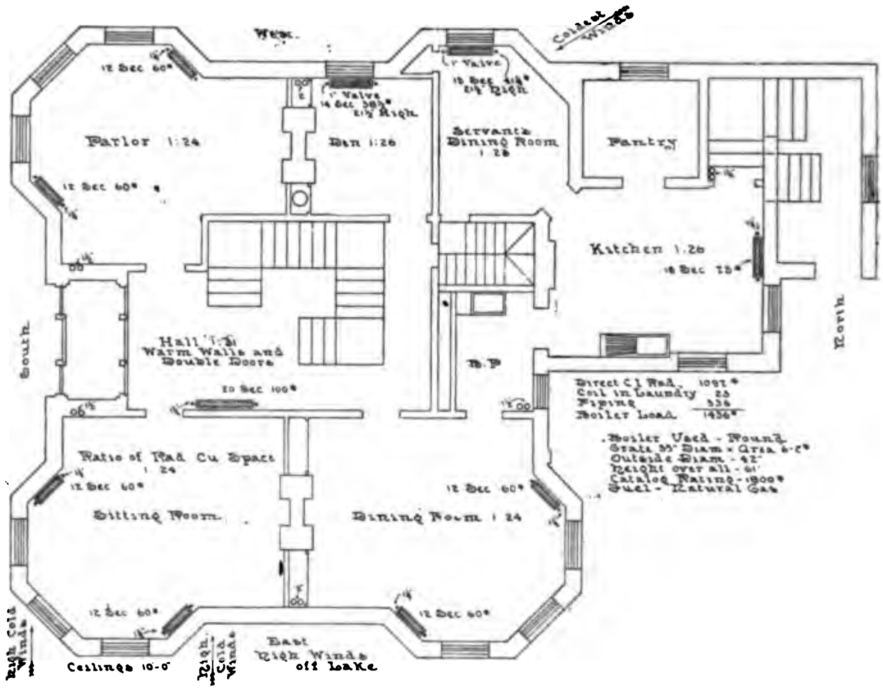

FIG. 62—RESIDENCE, FIRST FLOOR PLAN.

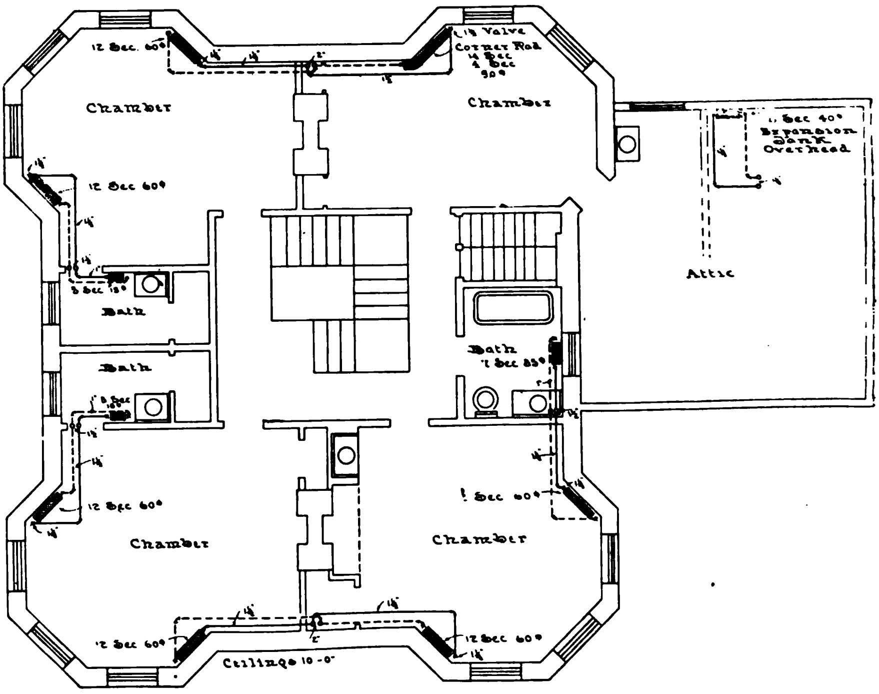

FIG. 63—RESIDENCE, SECOND FLOOR PLAN.

boiler, with a grate 35 inches in diameter, the area of which is 6.7 square feet. The outside diameter of the water heater is 42 inches; the height from floor to top, 61 inches. The catalog rating is 1,800 feet.

The fuel used for the first four years was natural gas. Since that time they have been using coal, and the only difference they find is in the trouble of taking care of the fire, after their experience with natural gas, which was automatic in its action.

The reason for using the one-pipe circuit system is because the radiation is all placed around the outside walls, and it is more convenient and takes less piping to do it in this way than in any other. As will be seen by the piping, which is very clearly laid out, the flow and return water travel in the same pipe, the hot water at the top and the cooler water at the bottom. The flow pipe is taken off the top and the return pipe enters the side of the main.

In this system it is, of course, necessary that the pipes pitch downward from the boiler. In this particular installation the pipe runs level from the boiler to the first two tees on the 3-inch line, the branches from these tees being taken off the top of the pipe and attached to the radiators, one on the first floor, the other on the second, relieves the pipe of air at that point through these two radiators. The two lines of pipe are carried around the basement, as shown, until they reach the boiler, where they drop to and are connected into the bottom of the fire pot.

The chimney in this house is in rather an awkward place, involving a long smoke pipe, which in some places might give trouble in starting a fire, owing to the cold air lying in it, but in this particular case the basement is quite warm because of the heat radiated from the uncovered piping, and probably for this reason there never has been any trouble with the chimney draft.

CHAPTER XV.

PLANS OF AN INDIRECT STEAM HEATING APPARATUS SUPPLANTING A HOT AIR FURNACE AND USING SAME WARM AIR DUCTS AND REGISTERS—A 900 FEET BOILER CARRYING A LOAD OF 1,800 SQUARE FEET.

FIGS. No. 77, 78, 79 and 80, is a steam-heating plant, which takes the place of a hot-air furnace, without making any changes in any of the rooms, with the exception of the kitchen and the toilet room on the first floor, one bedroom and bathroom on the second floor and ballroom on the third floor, these few rooms being heated by direct radiation.

The owner of this residence was averse to seeing direct radiation in the rooms, and did not wish to have his floors taken up or any dirt made in the house. He was willing, however, that indirect radiation should be placed in the cellar, and that the fresh air should be taken from a remote point in the basement, allowing it to be tempered by the warmth in the cellar before entering the heating stacks. This saved the expense of running separate air ducts to all of the indirect stacks. The only stack which was completely inclosed was the one under the dining-room, which received its air supply from the hall, as shown by the drawings. This was the arrangement connected to the hot-air furnace, and the owner did not wish to have it discontinued, as he thought it drew the cold air from the floors, which it undoubtedly did. All the other stacks were inclosed with wood, lined with tin and left open at the bottom.

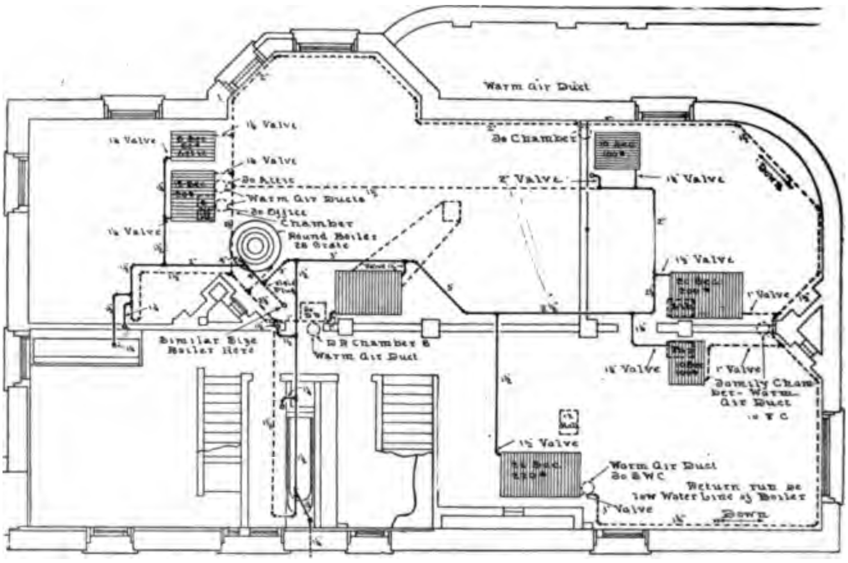

FIG. 77—PLAN OF A SUCCESSFUL INDIRECT STEAM JOB. RESIDENCE, BASEMENT PLAN

The pipes in the basement were all thoroughly covered, and a gate valve was attached to the steam and return ends of each radiator. Where the return dropped from the stack it was carried below the water line of the boiler and then connected into the line of a return pipe, which was carried around the basement wall to be out of the way until it reached the return of the boiler.

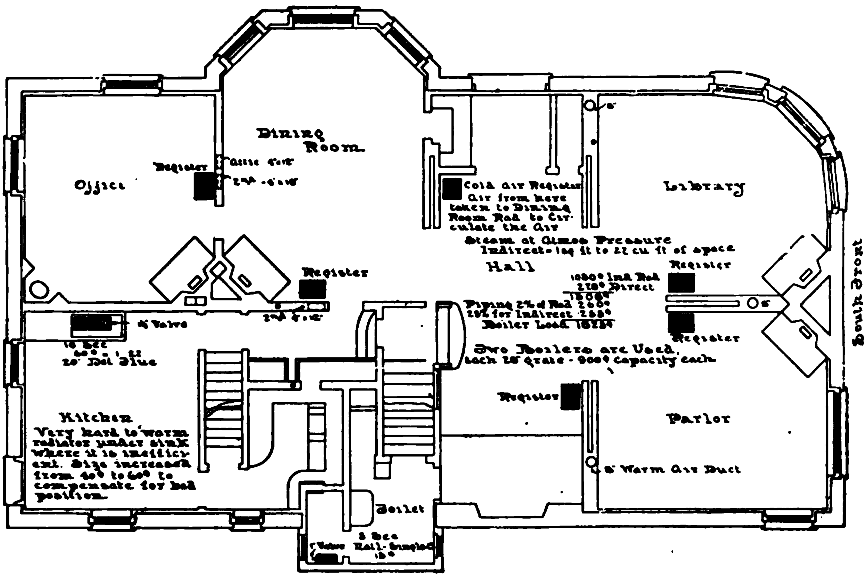

FIG. 78—PLAN OF A SUCCESSFUL INDIRECT STEAM JOB. RESIDENCE, FIRST FLOOR PLAN

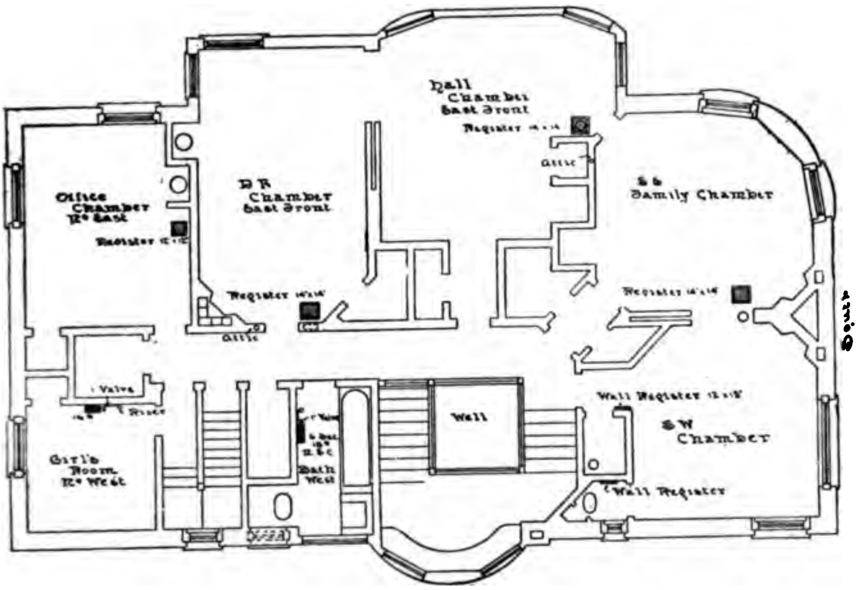

FIG. 79—PLAN OF A SUCCESSFUL INDIRECT STEAM JOB. RESIDENCE, SECOND FLOOR PLAN

The air ducts and registers which were used for the hot-air furnace were not changed in any manner. The stacks were set as close to them as possible, and in some cases were set directly under them.

A direct radiator was placed in the kitchen because it had never been warmed, and the only available space for it was under a sink, where there was very little chance for a circulation of air, and as a consequence the size of it was increased about 50 per cent. more than is customary for a room of that size.

It was not considered practicable to heat the ballroom on the third floor through the existing air ducts, and to that room were run two risers connected to direct radiation.

In the basement was placed one boiler with a little more than one-half the required capacity. The owner of the house, who was a large manufacturer, intended to make a special boiler in his own shops to install alongside the cast-iron boiler at a later time, but instead of this he neglected the matter until cold weather came on, and, finding that one boiler was furnishing vapor sufficient to warm the house, he determined to go through the winter with it. Of course, the boiler was entirely too small, but by giving the fire careful attention and running it at a high rate of combustion they were able, during the entire winter, to keep the house as warm as desired, the boiler furnishing sufficient vapor to warm the indirect radiation.

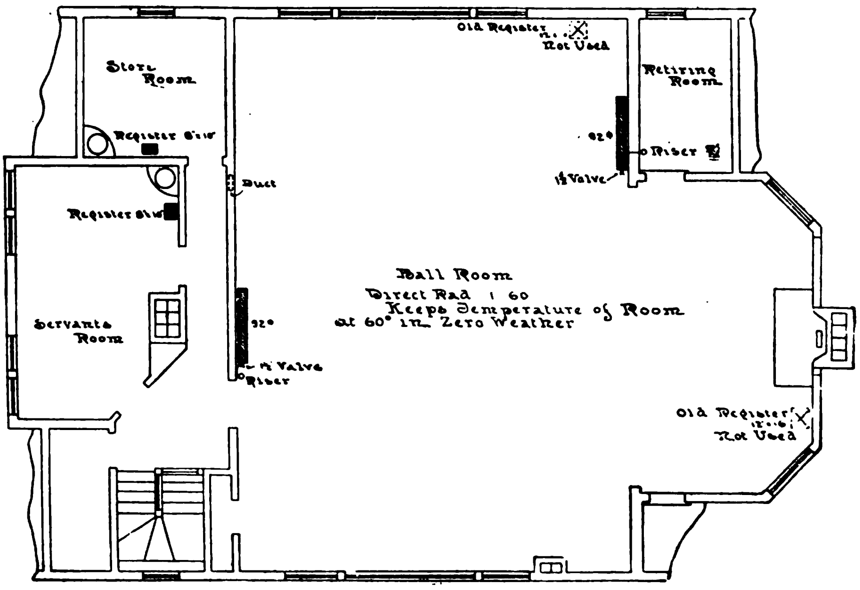

FIG. 80—PLAN OF A SUCCESSFUL INDIRECT STEAM JOB. RESIDENCE, THIRD FLOOR PLAN

Had this radiation been connected directly with the cold air, such a feat would have been impossible, but only enough air was let into the basement at large to keep it fresh.

This apparatus was installed in 1894. In 1895 a second boiler was cross connected with the first one. This second boiler is only used in the severe weather, as they find the first one will do all the work that is necessary in the fall and spring and the moderate weather during the winter.

The apparatus has been entirely satisfactory in every respect, every part of the house being thoroughly warmed, and these plans are now published with a view to showing what can be done in houses equipped with a hot-air furnace which is not giving satisfaction. There are many places where an indirect system such as this can be installed for less money than it would cost to put direct radiation in each room, and, besides that, the house is not cut up in any manner, the work all being done in the basement.

CHAPTER XVI.

PLANS OF A SUCCESSFUL WATER-HEATING APPARATUS WITH DIRECT AND INDIRECT RADIATION.

THE four plans, Nos. 68, 69, 70 and 71, show a hot-water heating apparatus which was placed in a $40,000 residence in 1896; so it has been in successful operation for eight winters.

Referring to the basement plan, Fig. 68. There are two boilers situated in the extreme rear end of the building, which is 100 feet deep. Each of these boilers has a fire pot 38 inches in diameter, which gives a grate area of 7.8 square feet. The outside diameter of the boilers is 45 inches, and they are 68 inches high. The catalog rating of the boilers is 2,500 square feet each, and for a temperature in the water below 180 degrees they are not over-rated.

These boilers are both attached to a chimney flue, 20 inches x 20 inches square and about 55 feet in height. From the boilers are run two lines of flow pipe, each 4 inches in diameter. These two lines of pipe are carried below the ceiling joists of the basement until they reach the billiard room, which is in the front of the basement, where they rise and are carried forward between the joists to the extreme front of the building.

The return pipe is laid in a concrete trench in the hall of the basement floor, and is covered with cast-iron trench plates made in sections, each about 36 inches long. This trench is kept close to the wall, and wherever the branch is connected to the main return, the trench plates are so arranged that the joint comes at that point, one-half of the diameter of the pipe being cut out of each plate where they match together, as shown in sketch, Fig. 72.

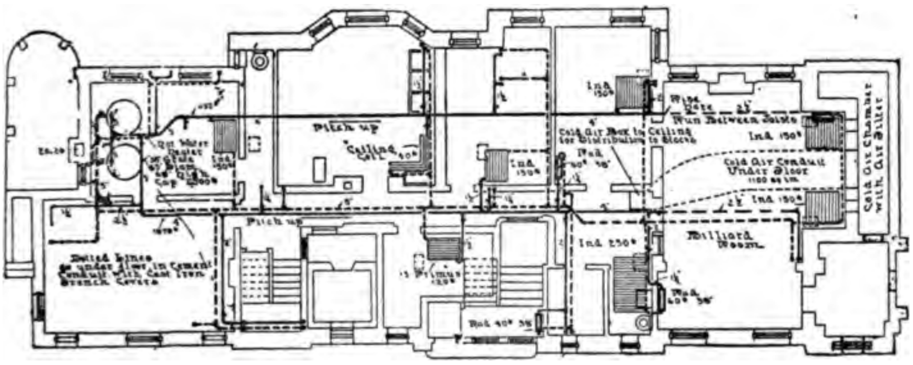
Pitch up
Ceiling Coil 60'
Hot Water Heater
Ind. 150'
Pitch up
Dotted lines go under floor in cement conduit with cast iron trench covers
Ind. 150'
Wine Vats
Run Between Joists
Cold Air Box in Ceiling for Distribution to Stacks
Rad. 40" 36"
Ind. 150'
Cold Air Conduit Under Floor 1100 sq in.
Ind. 150'
Ind. 150'
Cold Air Chamber with Air Filter
Ind. 250'
Billiard Room
Rad. 40" 36"
Rad. 40" 36"

FIG. 68—BASEMENT PLAN OF RESIDENCE 8 FT. 6 IN. IN CLEAR; 269 SQ. FT. DIRECT RADIATION FOUR RADIATORS. ONE COIL PIPING OVERHEAD UNCOVERED

As the first floor of this residence is warmed by indirect radiation, the indirect stacks for same are hung in the basement beneath the floor joists, the heavy ones being suspended by one or more columns made of 2-inch pipe with floor flanges, as was shown in detail in a former article.

The air supply for these indirects is taken from the front of the building into a cold air or settling chamber, which is fitted with removable cheese cloth filters which effectually prevent any dust from entering the rooms through the registers. As this fresh-air duct could not be carried on the ceiling of the billiard room, it was necessary to put it under the floor, and to make it perfectly safe and free from sewer gas, heavy vitrified tile pipe was used with cement joints. As this could not be put into a single pipe, two pipes were used side by side, the combined area of these two pipes being 1,100 square inches.

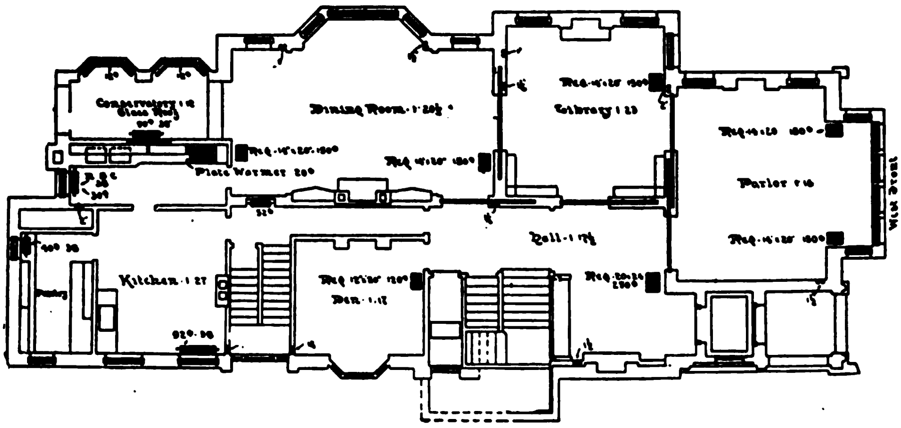

FIG. 69—FIRST FLOOR PLAN OF RESIDENCE; 11 FT. 4 IN. HIGH IN CLEAR; WINDOWS 8 FT. HIGH 1120 SQ. FT. INDIRECT RADIATION; 7 STACKS AND REGISTERS 348 SQ. FT DIRECT RADIATION; 5 RADIATORS, 3 COILS

After passing under the billiard room floor the air was then carried to the ceiling in a wooden box and distributed to the various stacks from that point along the ceiling.

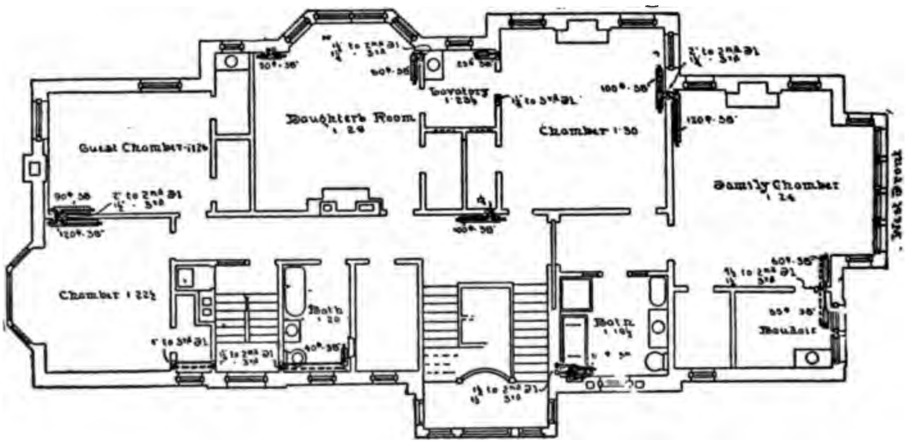

FIG. 70—SECOND FLOOR PLAN OF RESIDENCE; 10 FT. 6 IN. HIGH IN CLEAR; WINDOWS 7 FT. HIGH

At the boiler there were cut-off valves on flow and return pipes so that either boiler could be cut out in case of emergency, and to prevent an accident in case of a fire being made in a boiler before the valves were opened, there was placed on each boiler a reliable pop safety valve 2 inches in diameter.

Every flow and return pipe leading from the mains was valved and furnished with a ¾-inch steam cock, to which could be attached a ¾-inch garden hose. By shutting off these valves and drawing the water out of a group, radiator repairs could be made in the event of leak or accident, without shutting down any part of the plant except the two or three radiators on a given line. These valves are somewhat unusual as they add quite a little to the cost of installation, and few owners care to pay for the additional expense.

The flow pipes in the basement were not covered, but the return pipes in the conduit were thoroughly covered to prevent loss of heat.

In the entire building there were 34 direct radiators, containing 2,029 square feet; there are seven indirect stacks, containing 1,120 square feet, making a total of 3,149 square feet of radiation. The piping will aggregate 30 per cent. of this, or 950 feet, and as the air was tempered by the inside air before entering the radiators, there was added for additional cooling power to indirects 50 per cent. or 560 feet, which made a total boiler load of 4,659 square feet.

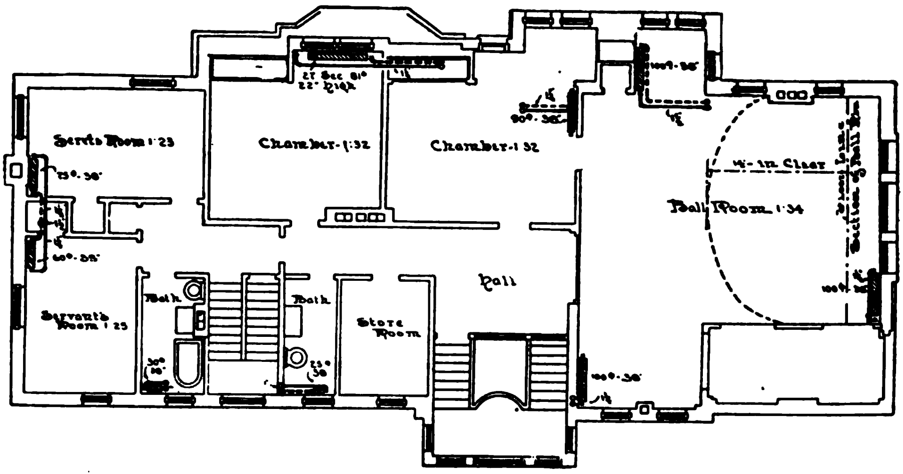

FIG. 71—THIRD FLOOR PLAN OF RESIDENCE; 10 FT. HIGH IN CLEAR, EXCEPT BALL ROOM; WINDOWS 7 FT. HIGH; 9 DIRECT RADIATORS 661 SQ. FT.

The boilers selected, as before stated, were rated by the makers to carry 5,000 square feet, and they have proved to be of ample capacity; no change having been made in the apparatus in any manner since it was installed.

The height of ceiling in first floor is 11 feet 4 inches in the clear. The windows are 8 feet high. On the second floor the height of ceiling is 10 feet 6 inches in the clear, windows 7 feet high. In the third floor, the height of ceiling is 10 feet in the clear, windows 7 feet high. In the ball room, which has an arched roof, the extreme height is 14 feet, as shown in section.

The necessary radiation for this residence was computed by the heat transmission rule for direct radiation, adding 50 to 75 per cent. for the indirect. Not a very exact method. Figuring from cubic contents alone, the ratio of indirect in the parlor is 1 to 16; in the library, 1 to 23; in the hall, 1 to 17½; drawing room, 1 to 20½; den, 1 to 17; kitchen, 1 to 27 direct; conservatory, 1 to 12 direct. The second floor is all direct. Family chamber figures 1 to 24; south chamber, 1 to 30; daughter's room, 1 to 29; guest chamber, 1 to 36; northeast chamber, 1 to 22½; bath rooms, 1 to 20.

The third floor is all direct and the ratio figures: Bath room, 1 to 34; south chambers, 1 to 32; southeast chamber, 1 to 23; northeast chamber, 1 to 25.

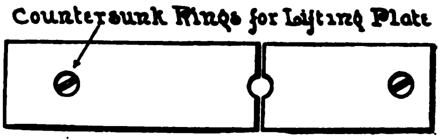

FIG. 72—C. I. TRENCH PLATE, SHOWING OPENING IN JOINT FOR RISER

The direct radiators are first given a coat of priming, and are then decorated in tints to correspond with the tint of walls, so that they are not at all conspicuous.

The indirect registers are electroplated to harmonize with the floors. In the dining room, which is finished in Flemish oak, the register is a dark bronze, while in other rooms which have light oak floors, the electroplating is made to harmonize with the light oak.

CHAPTER XVII.

PLANS OF A WATER-HEATING APPARATUS WITH DIRECT WINDOW RADIATION—PLANS OF A DIRECT AND INDIRECT WATER-HEATING APPARATUS—PLANS OF A STEAM-HEATING APPARATUS IN A TWO-FLAT BUILDING.

FLOOR plans Nos. 73, 74, 75 and 76 represent hot-water heating plans for a fine residence, the radiation being nearly all composed of window radiation.

Referring to the basement plan, No. 73, there are two round cast-iron boilers, each of 1,200 feet capacity. These boilers have grates 28 inches in diameter.

The entire amount of radiation in the building is 1,391 square feet. The piping and underground radiation bring the cooling surface up to an equivalent of 1,800 square feet for the boiler load. The piping is so arranged that the flow and return water traverse the same pipe, the flow being taken out of the top and the return entering the side of the main. Two lines of pipe are run, a 3-inch circuit for the front of the house and a 4-inch for the rear.

The basement radiators are fed off the side of the pipe and return under the concrete, the radiators standing on a pedestal 12 inches in height to increase the circulation of water through the radiators, as there was no opportunity to increase the circulation by running up to the second floor, as would have been done had there been an opportunity.

Turning to the second floor; the pipes connecting the window radiators are

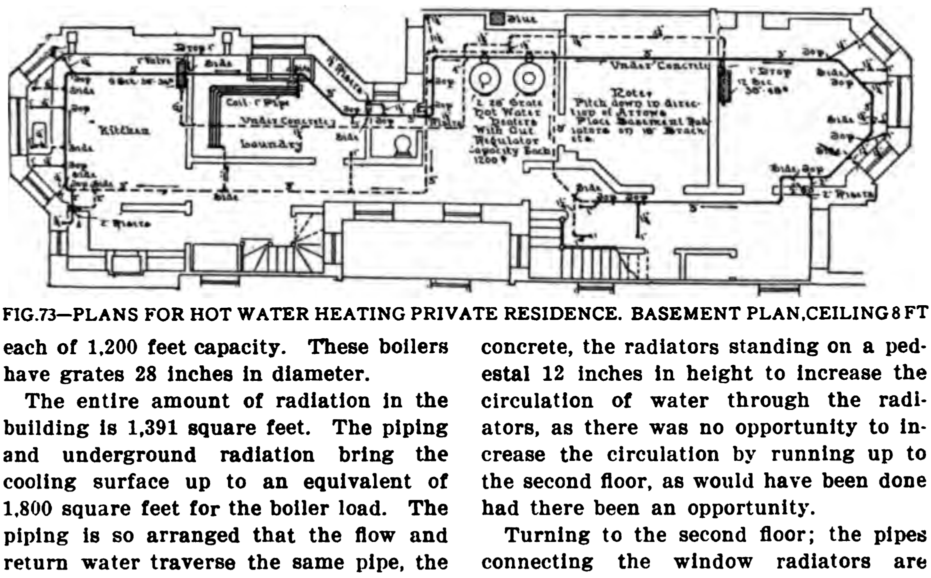
Kitchen
Laundry
Coil 1" Pipe
Under Concrete
Under Concrete
Note
Pitch down in direction of Arrows
Place Basement Radiators on 12" Brackets
2 28" Grate Hot Water Heaters With Out Regulator Capacity Each 1200
1" Drop
12 Sec. 38"-48"
2" Risers
Flue

FIG.73—PLANS FOR HOT WATER HEATING PRIVATE RESIDENCE. BASEMENT PLAN,CEILING 8 FT

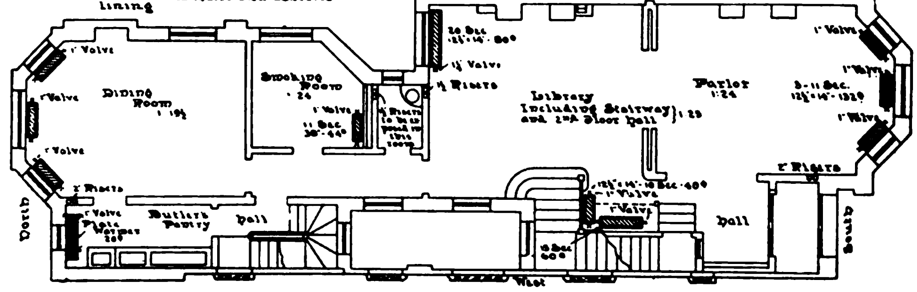

FIG. 74–PLANS FOR HOT WATER HEATING. FIRST FLOOR PLAN, 10 FT. 6 IN.

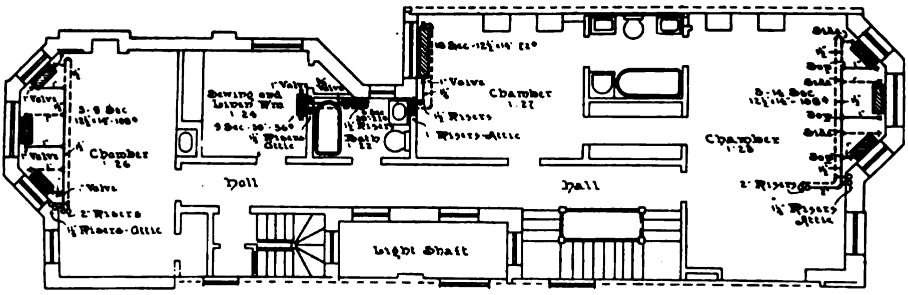

FIG. 75—PLANS FOR HOT WATER HEATING SECOND FLOOR PLAN, 10 FT. CEILING

shown on the plan, as they appear between the floor and ceiling of the first floor, and here, as in the basement, the flow pipe is taken off the top of the pipe and the return enters the side. By this method but one set of risers is necessary.

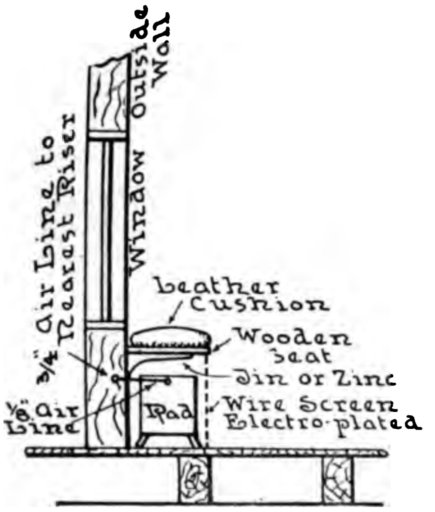

FIG. 77—SHOWING CORRECT METHOD OF PLACING WINDOW SEAT OVER RADIATOR

The correct method of setting these window radiators is shown in Fig. 77, where the radiator is set out from the wall about 2 inches, and between the top of the radiator and the bottom of the wood seat is a space of 3 inches. From the bottom of the front part of the wood

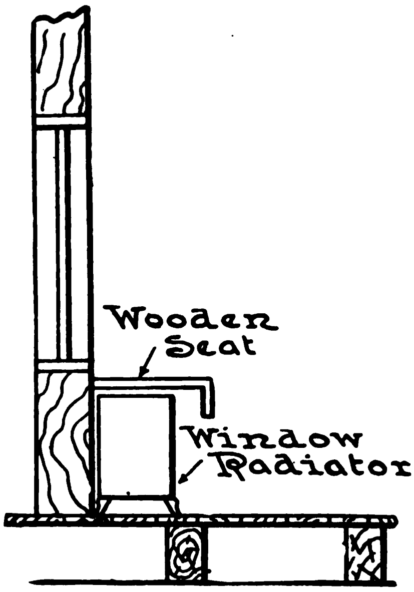

FIG. 78 - INCORRECT METHOD OF PLACING SEAT OVER WINDOW RADIATOR

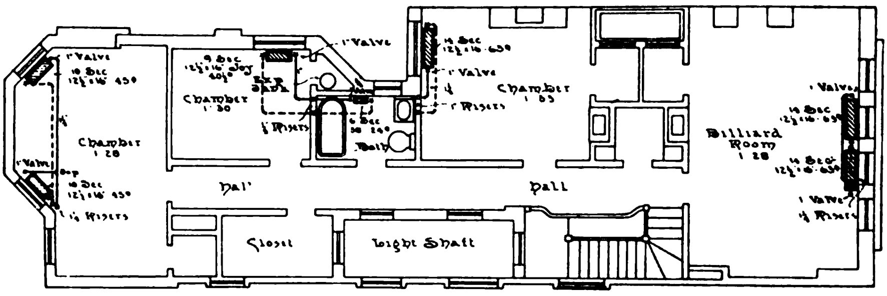

FIG. 76—PLANS FOR HOT WATER HEATING. THIRD FLOOR PLAN, 10 FT. CEILING

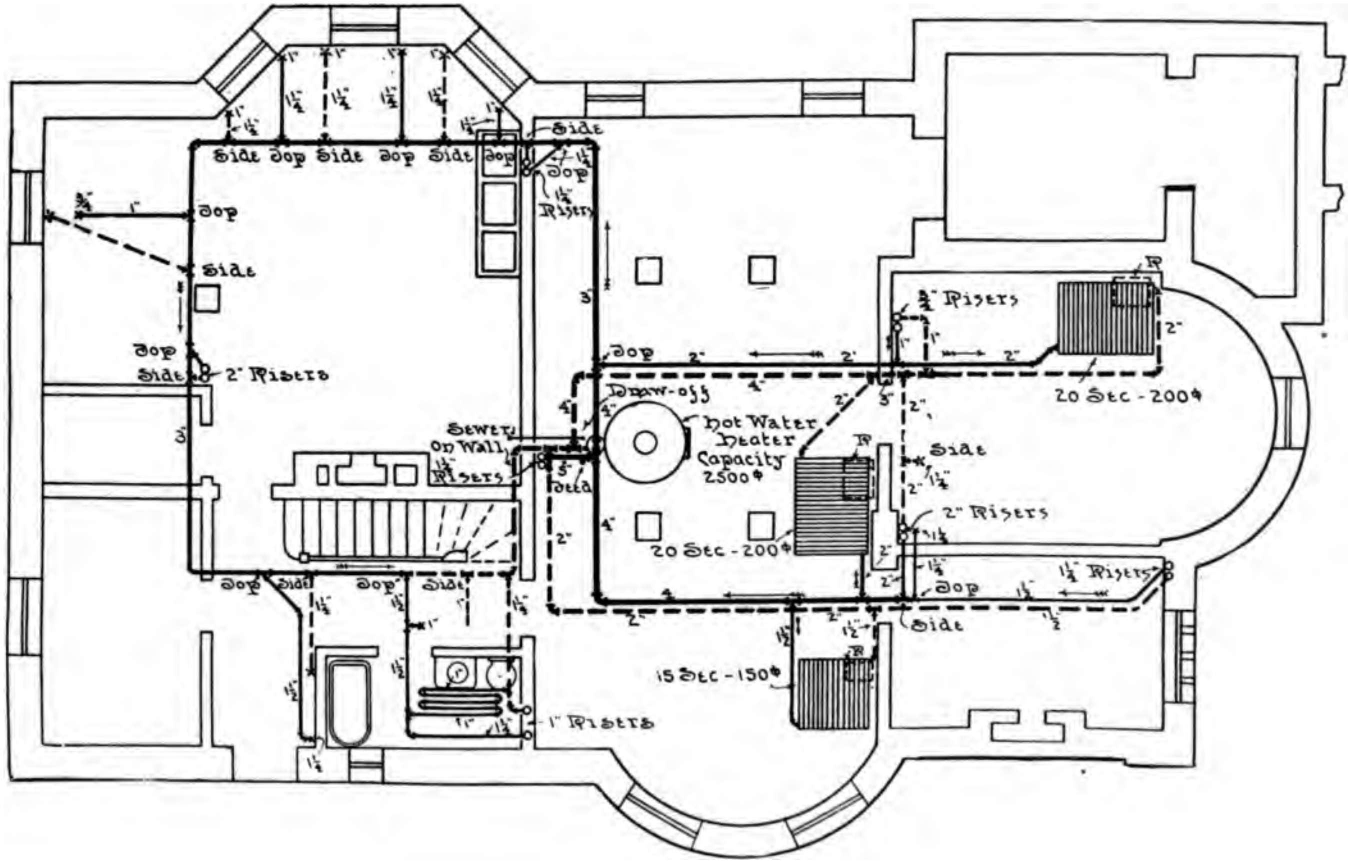

FIG. 79—PLANS FOR HOT WATER HEATING. SHOWING BASEMENT PLAN OF A RESIDENCE, WITH 8 FT. CEILING

seat to the back wall and thence extending to the floor, is a sheet metal lining made either of zinc, sheet tin, or light galvanized iron. This metal lining gradually rises from the back to the front of the radiator so that the air, in passing under the radiator and rising to the top, will have a free outlet at the front of the window seat.

An incorrect method of setting window radiators is shown in Fig. 78. In this sketch, the radiator is shown set close against the back wall with the window seat set close to the top, and in front of the seat a wood curtain, which effectually boxes in the radiator and prevents a free circulation of the heated air into the room. Most men looking at this sketch

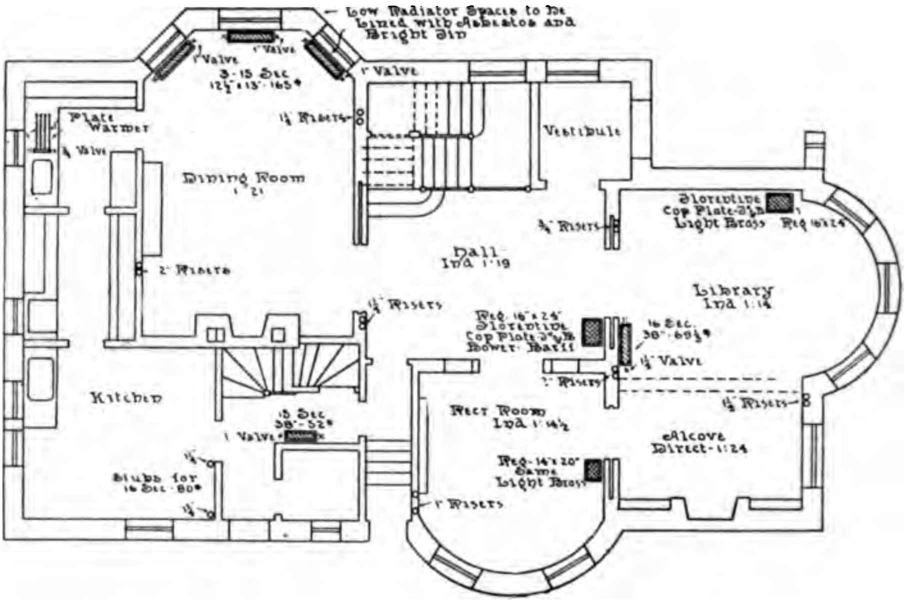

FIG. 80—PLANS FOR HOT WATER HEATING. THIRD FLOOR PLAN, 10 FT. CEILING

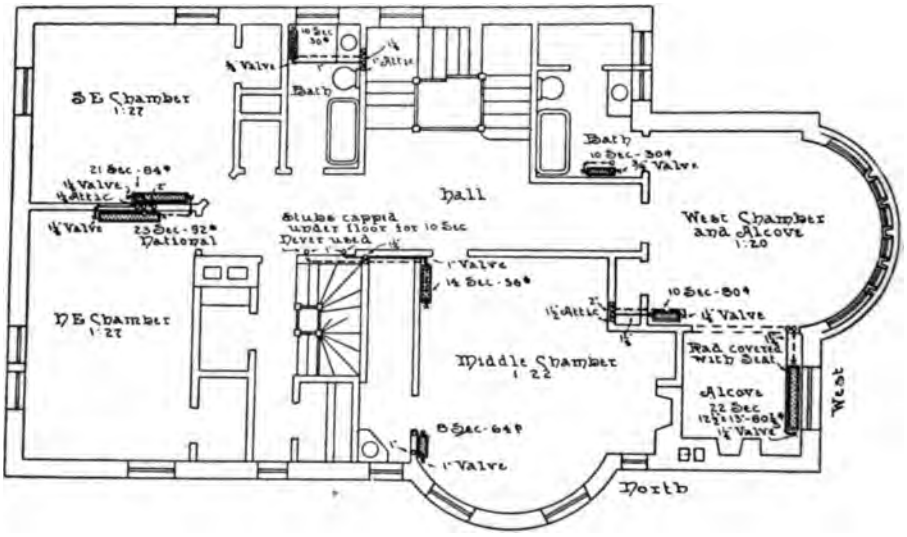

FIG. 81—PLANS FOR HOT WATER HEATING. SECOND FLOOR PLAN, CEILING 10 FT. 3 IN.

would say that it was an exaggeration, but it is a fact that in many instances window radiation is placed in the manner described, and then the parties interested wonder why it does not heat the room. It should be remembered that window radiation heats the air almost entirely by convection; that is, the air from the floor enters the radiator at the bottom, and passing up through it is warmed, and these warm currents heat the air in the room. When a close top is placed on a radiator, it detracts very largely from its efficiency, but when tops or seats are placed as shown in Fig. 77, the radiator will do very efficient work.

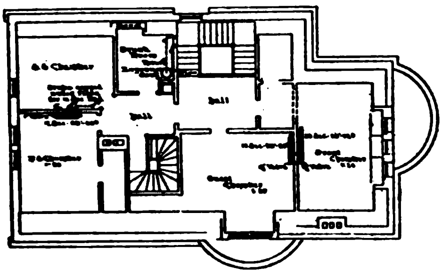

FIG. 82—THIRD FLOOR PLAN, CEILING 9 FT

The apparatus described was installed in 1893 and has been very satisfactory in every respect. The radiation in the basement rooms is figured 1 to 23. This seems very high, but this was done to compensate for the lessened efficiency of the basement radiators, which do not circulate as well as do the radiators on the upper floors. In the dining room on the first floor, radiation is figured 1 to 19½; in the parlor, 1 to 24; in the library, 1 to 25. On the second floor, the rooms are figured from 1 to 22 to 1 to 27, and on the third floor from 1 to 28 to 1 to 33.

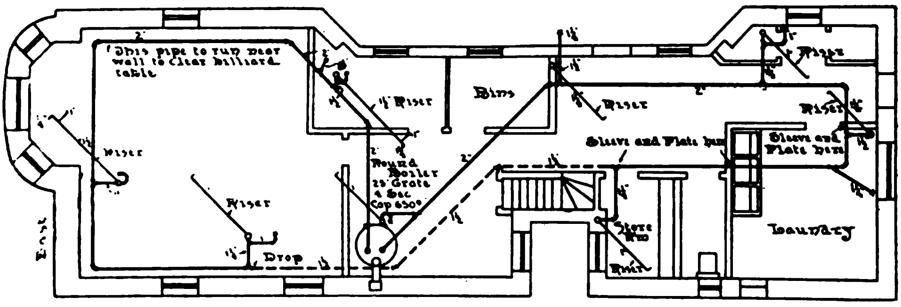

FIG. 83—PLANS FOR STEAM HEATING. BASEMENT PLAN TWO FLAT BUILDING

Floor plans Nos. 79, 80, 81 and 82 show a direct and indirect hot-water heating apparatus in a fine residence in one of our large cities.

In this apparatus are 1,589 square feet of direct and indirect radiation. For the boiler load we add 275 feet for the increased cooling power of the indirect and 450 feet for the piping, making a total load of 2,314 square feet.

The heater has a 38-inch gate, is 45 inches outside diameter and stands 68 inches high, being rated to carry 2,500 square feet. The apparatus was designed to heat the building in zero weather, with the water leaving the boiler at 160 degrees, and the specifications, in this regard, have been fully carried out.

In this installation, the direct radiation is carried on a one-pipe circuit, the flow being taken out of the top of the pipe and the return entering the side. The indirect is connected to a flow and return system, the height of the cellar being such that the returns are carried along the ceiling instead of being carried underneath the floor, as is customary.

The ratio of indirect radiation to cubic contents is 1 to 19 in the hall; 1 to 14½ in the reception room; 1 to 14 in the library, the direct radiation being figured from 1 to 20 to 1 to 27.

The valves and registers in this house were all plated to match the wood work, and made a very handsome appearance when finished. This is a good example of a mixture of direct and indirect hot water heating in a modern, high price residence.

Floor plans Nos. 83, 84 and 85 reprosent a small, two-story flat building which is heated by low-pressure steam. There is very little to say about this installation except that there are 495 square feet of radiation in the building, to which we add 100 square feet for the piping, making a total of 595 square feet. The steam boiler is a round, cast-iron sectional boiler with a 25-inch grate and four sections over the fire, being rated by the manufacturers to carry 650 square feet.

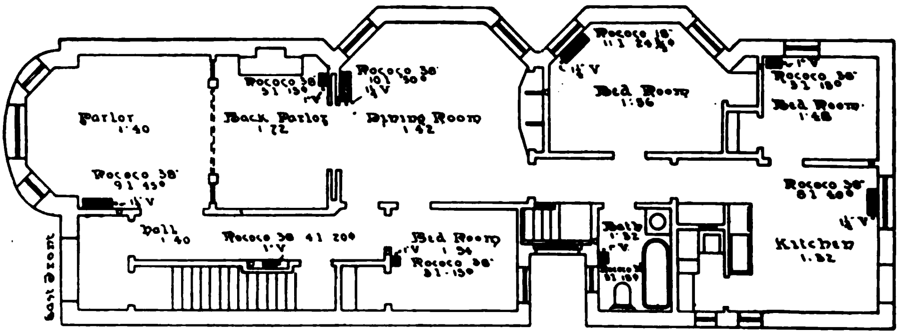

FIG. 84—FIRST FLOOR PLAN TWO FLAT BUILDING, 10 FT. CEILING, 19 RADIATORS, 496 SQ. FT.

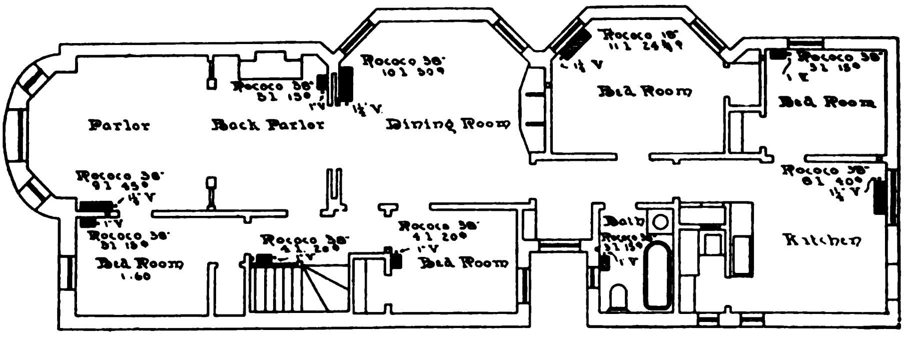

FIG. 85—SECOND FLOOR PLAN TWO FLAT BUILDING, 10 FT. CEILING

The piping is divided into two circuits, the front and back being equally divided.

This installation is a fair example of the present method of steam heating in an ordinary flat building.

Turning to Fig. 84, which is the first floor plan, we find the parlor, which fronts east is figured 1 to 40; the back parlor, which has no windows and is lighted from the front, is figured 1 to 72; the dining room is figured 1 to 42; the bedroom with a south exposure is figured 1 to 56; the rear bedroom, 1 to 48; the kitchen, 1 to 32; the other bedroom, 1 to 54, and the hall 1 to 40. This ratio of heating surface was found to be quite enough for severe weather, and as the job has been in operation since 1896 without any repairs or alterations, it is fair to assume that the apparatus has been satisfactory to the owners.

CHAPTER XVIII.

DIRECT WATER HEATING APPARATUS IN CITY BLOCK.

THE floor plans shown herewith, Figs. 86 to 89, inclusive, represent a city house, built in a block. The material is brick on sides and back, and cut stone front, the roof being the usual flat roof covered with tar and gravel. The quantity of radiation in the different rooms was computed and specified by the architect, who, in his anxiety to have sufficient radiation, called for more than was actually required. The size of each room with the glass and wall exposure, is figured on the plans, and the ratio to cubic contents of the radiation is also shown.

In the following table we show in the first column the radiation installed in each room and in the second column the radiation required, the latter figures being computed from the heat transmitted, assuming that the house is to be kept at 70 degrees when the external temperature is zero, and with one change of air per hour.

	Radiation Installed. Sq. ft.	Radiation Required. Sq. ft.
Basement	56	56
Laundry	20	20
First Floor—		
Parlor	110	75
Hall	168	82
Sitting room	84	56
Dining room	126	85
Plate warmer	10	10
Kitchen	90	75
Second Floor—		
Front chamber	120	95
Hall	84	60
Main chamber	80	54
Bed room	56	48
Bath room	59	59
Rear chamber	64	68
Alcove	28	26
Attic	120	80
Hall	28	28
Servants' room	44	38
	1347	1015

Excess radiation 332 square feet.

By this table it will be seen that the excess radiation is 332 square feet. The apparatus has been in operation about ten years, and has always worked very satisfactorily, but owing to the excessive amount of radiation, the water in the boiler is rarely carried above 130 degrees.

By referring to the basement plan of this house it will be seen that the main flow pipe leaving the boiler is 4 inches. This runs on a level until a 3-inch branch is taken off the side, and a 2½-inch branch off the end. The first tee of the 3-inch branch comes off the top and is carried to a riser, which relieves the entire system of air, as the mains pitch down away from the boiler, from the junction of the 3-inch and 2½-inch pipes. The 3-inch main is carried along the ceiling near the north wall, until it reaches the west end of the basement. Here it turns south, until all the radiation and risers are taken off, when it drops and is carried back to the boiler beneath the concrete floor in a trench prepared for the purpose.

As will be seen by the plans, a part of the radiators return the water into the same pipe from which the flow is taken. Another portion of the radiation is fed off the flow pipe, and the returns are dropped into the main return, which runs under the floor. The circulation of the water in the apparatus is excellent.

The boiler installed on this apparatus has a round fire pot 35 inches in diameter. The outside diameter of the boiler is 42 inches and the height 60 inches. It is connected to an 8-inch by 12-inch tile chimney, with 9-inch round smoke pipe. The boiler is rated to carry 1,850 square feet, with the water leaving the boiler at 180 degrees. There are connected to this boiler twenty-seven radiators, containing

1,327 square feet, to which we may add 400 feet for the pipe, making 1,727 feet. Inasmuch as it is not necessary to heat the water above 130 degrees, the boiler is, of course, of ample size.

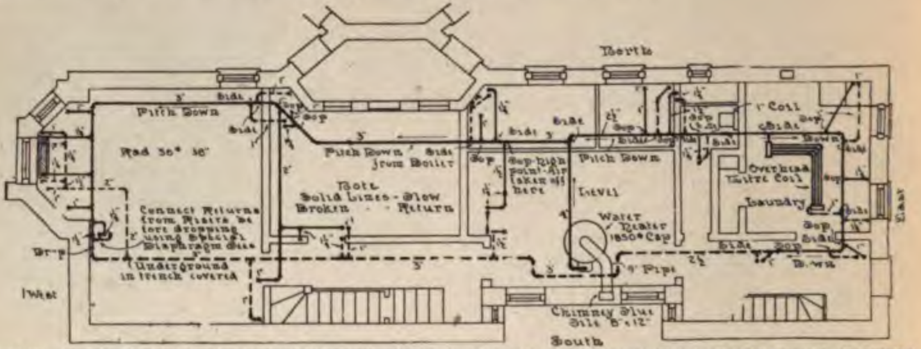

FIG.86—BASEMENT PLAN OF TWO RESIDENCES SHOWING ARRANGEMENT OF HEATING SYSTEM

Turning to the first floor, the radiation for the parlor is placed under a seat. The seat is 4 inches above the top of the radiators, and is lined with light galvanized sheets, both back and top of radiator, the lining curved to admit of an easy flow of the air into the room after it passes through the radiators. There is also a low radiator under a seat at the foot of the stairs.

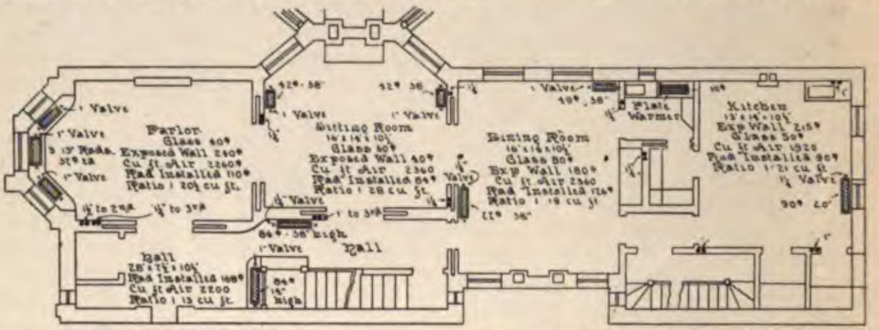

FIG. 87—FIRST PLOOR PLAN OF A CITY RESIDENCE, SHOWING LOCATION OF RADIATORS, ETC

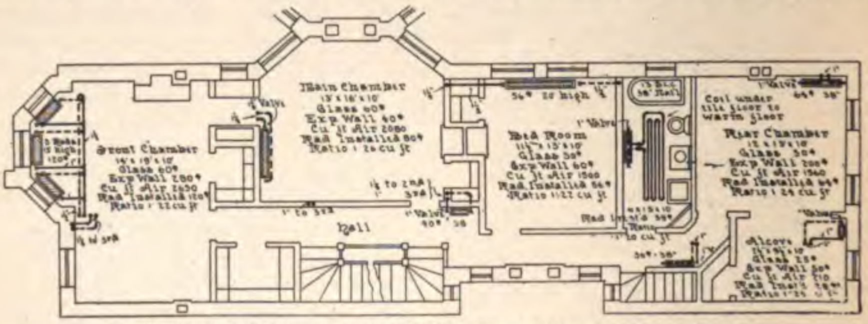

FIG. 88—HEATING A CITY RESIDENCE, SECOND FLOOR PLAN

It will be noticed by reference to the table that the radiation in the hall is just about double the quantity required, because the hall will only lose its heat to the upper hall, and that being thoroughly warmed, there is really very little loss of heat, and, as a matter of fact, the parlor and sitting room radiators were frequently shut off, even during the winter, there being sufficient heat in the hall for all of these rooms.

In the butler's pantry on this first floor, there is a plate warmer, made of pipe coil, which is a very great convenience to the housewife.

On the second floor the radiation in the front room is also placed under a seat, and in the bath room will be noticed a pipe coil which is placed under the floor to give warmth to the tile flooring. To permit of the introduction of this coil the bath room floor was lowered two feet, and the ceiling beneath the bath room floor was made of paneled wood. put up in such a manner that it could be easily taken down to give access to the coil, in the event of its requiring repairs.

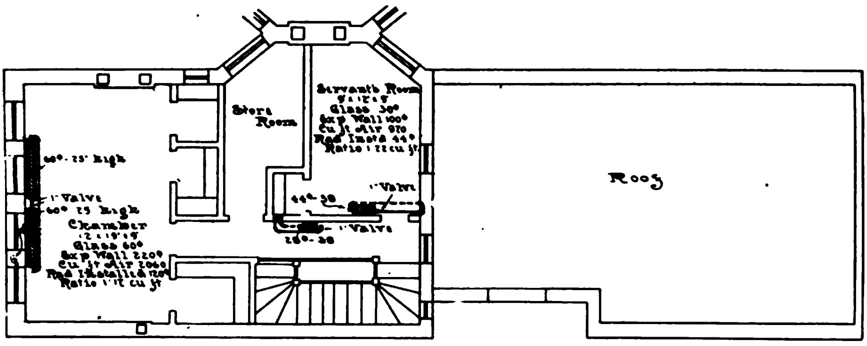

FIG. 89—THE ATTIC FLOOR PLAN, SHOWING SERVANTS' ROOM AND STORE ROOM

The air was taken from this coil by a $\frac{3}{4}$-inch vent pipe, which connected to the flow pipe leading to the bath room radiator.

In the rear chamber it will be noticed by reference to the table, that the radiation installed is 4 feet less than the quantity required, but this is the only room in the house in which the radiation is not largely in excess of requirements.

In the attic there are four radiators, two low radiators in the front room, one in the servant's room, and one in the hall.

The only objection that can be urged to placing so much radiation in this house is the wall and floor space that it occupies.

Where the owner and architect are willing to pay for more radiation than is required, that is their lookout, but where radiation is figured by a heating contractor, under keen competition, he will find it greatly to his advantage to know exactly how much radiation is necessary to warm a given space. Many a man has lost a job of heating because he figured more material than was necessary to do the work.

CHAPTER XIX.

PIPING PLANS FOR WATER HEATING IN A SMALL CITY RESIDENCE—FIGURING RADIATION BY HEAT TRANSMISSION.

THE floor plans shown herewith represent a small city residence, warmed with a hot water heating apparatus. The lower floor is warmed with indirect radiation and the second floor with direct. There are 336 feet of direct radiation and 480 feet of indirect.

In selecting a boiler of the proper size for this work, we add 50 per cent. to the indirect, or 240 square feet, and 250 feet for mains and risers. This will make a total of 1,336 square feet. To take care of this radiation a round boiler was selected, having a 32-inch fire-pot, which gives us a grate area of 5.6 square feet. The outside diameter of the boiler is 40 inches and the height 60 inches. Figuring both sides of the horizontal surfaces inside the heater, there was 85 square feet of heating surface.

This heating apparatus was installed about nine years ago, and has been very satisfactory in every respect.

The cold air is taken from the cellar at large, and the cellar air is kept clean and sweet by a system of ventilation from distant points. This keeps the cellar air comparatively cool and tempers it somewhat before entering the indirect stacks.

The main flow pipe for the rear end of the building is 2½ inches, and pitches up from the boiler to the point marked on the plan "High Point." From there it pitches down toward the boiler until it reaches the point marked on the plan "Drop Here," where it drops to within 18 inches of the basement floor and is then carried along the wall to the boiler.

The indirect stack of 150 square feet is fed from the side of this 2½-inch main by a 1½-inch branch, and the return enters the main return after the latter has dropped to a point near the floor line.

The direct radiation is taken off the top of this 2½-inch pipe and returned into the side, making it, in effect, a one-pipe circuit, with the exception of the indirect, which, as has been explained, discharges its return water into the main return after all other radiation has been taken off.

For the front of the building there is carried a 3-inch main, which rises until it reaches the place marked on the plan "High Point." From this point the pipe is carried across to the wall and dropped near the floor, the same as was done on the other line.

To supply the two indirect stacks with hot water, a 2-inch branch is taken off the side of the main, each stack being fed 1½ inches. The returns from these two stacks go back and drop into the main return line, after all other radiation has been taken off. The chimney flue for this plant is 12 x 12 inches, and is 35 feet in height. The pipe in the basement is not covered.

On the first floor there are two registers taken off the double stack; each register is 14 x 22 inches, and the heat from these two stacks takes care of the parlor, hall, reception hall, and hall and passage on the second floor.

In computing the radiation required for this building, it was estimated that the air would change in these rooms four times per hour, and that the air in the dining room, when the doors would all be closed, would change six times per hour, and the radiation was figured accordingly.

The risers, as will be seen by the

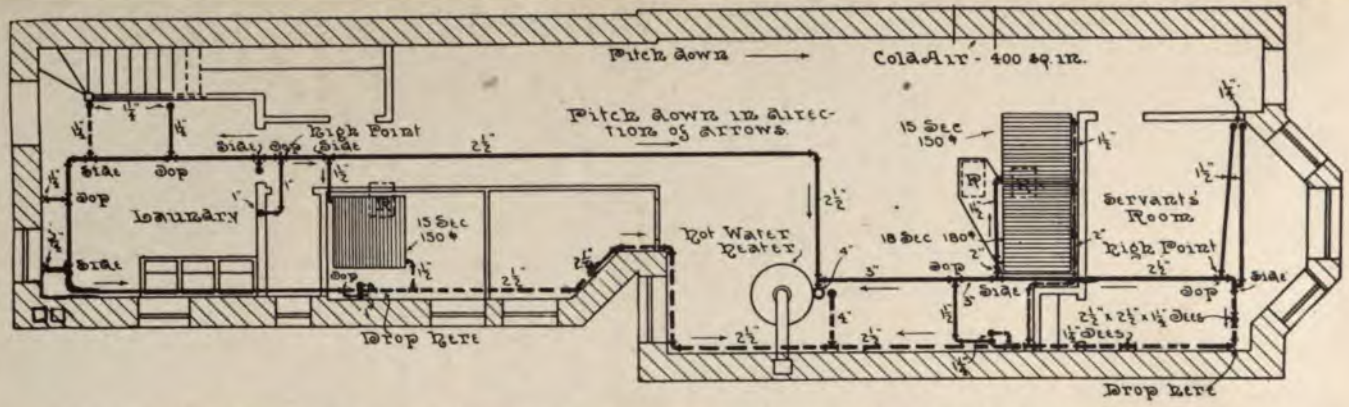

FIG. 90—BASEMENT PLAN OF A SMALL CITY RESIDENCE, SHOWING THE HOT WATER HEATING APPARATUS AND PIPING

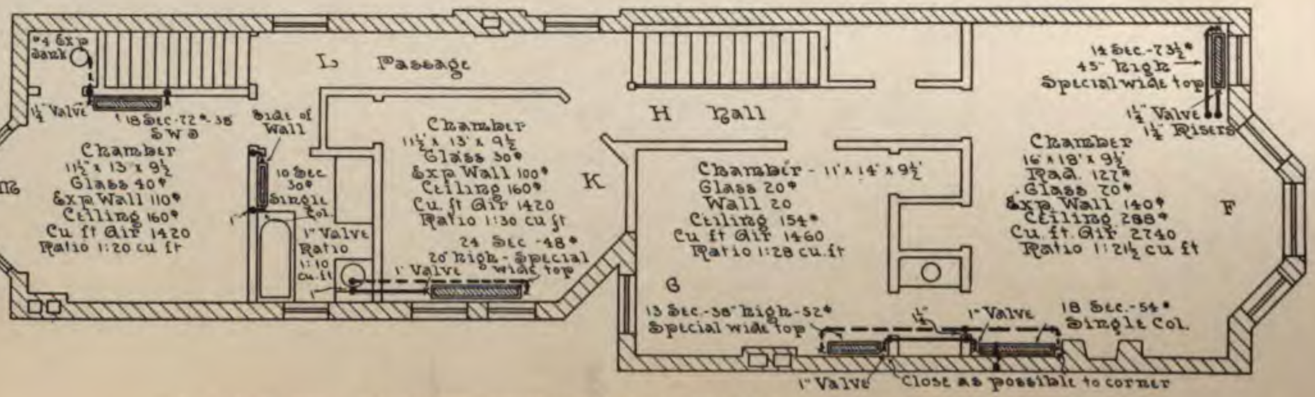

FIG. 92—HEATING A SMALL CITY RESIDENCE WITH HOT WATER, SHOWING SECOND FLOOR PLAN

plan are all concealed in the partitions.

On the second floor the radiation was all made with special wide tops, and were fitted with saddles carrying Mexican onyx tops. This, of course, would detract somewhat from the heating efficiency of the radiation, but the house being well built and the radiation ample, there has never been any difficulty in keeping up the temperature required in all kinds of weather.

The expansion tank is placed in the top of a closet opening off from room "M" on the second floor; the overflow from this, which is not shown in the plan, is carried back and drips into the laundry tubs. The tank, however, being of ample size, has never given any trouble in overflowing, and probably never will.

The size of each room is shown on the plans, the height of the first floor ceiling being 10 feet and the second floor 9 feet 6 inches. For the benefit of those who wish to make comparisons, we show on the plans the square feet of glass and exposed wall, also the cubic feet of air.

In this house we were obliged to make some allowance for the loss of heat through the ceiling of the second floor rooms, as there was a very small air space between the ceiling and the roof.

The temperature of the rooms is controlled by a Powers thermostat, which is placed in the dining room, the location of same being shown on the plan.

To warm all the rooms in this house equally to 70 degrees in zero weather, we first ascertain how much heat will be lost per hour by transmission and how much heat will be required to warm the incoming air.

From numerous experiments, we know that with indirect heating and a good aspirating chimney, the air in the rooms will change on an average four times per hour.

As there is an air space between the ceiling and roof, we will figure the loss of heat by transmission through the ceiling at 0.129 B. T. U. per square foot per hour for one Fahrenheit degree of temperature difference on the two sides, and as the air changes four times per hour and one B. T. U. will raise the temperature of 50 cubic feet of air one degree, we find the factor for one change of air 1.4, by dividing 70 by 50, and 1.4 × 4 = 5.6, as the multiplier for the air.

We have then multipliers as below:

	Multipliers.
Glass	72
Brick or stone wall	22
Ceiling under roof	9
Cu. ft. of air, change once per hour	1.4
Cu. ft. of air, change twice per hour	2.8
Cu. ft. of air, change 3 times per hour	4.2
Cu. ft. of air, change 4 times per hour	5.6
Cu. ft. of air, change 5 times per hour	7.0
Cu. ft. of air, change 6 times per hour	8.4

As the rooms A, B, C, on first floor, and on second floor the hall and passage, H L, are all figured as one room and are warmed with one stack of indirects, we proceed as follows:

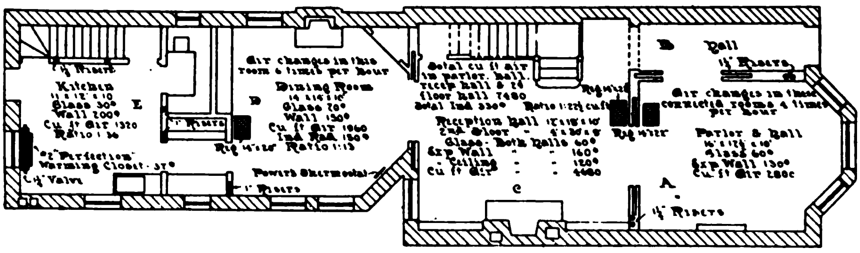

FIG. 91—FIRST FLOOR PLAN OF A CITY RESIDENCE HEATED BY HOT WATER

Glass	120 x 72	=	8,640
Wall	290 x 22	=	6,380
Ceiling, 2d floor	120 x 9	=	1,080
Cu. ft. air	7,480 x 5.6	=	41,888
Total heat required per hour in B. T. U.			57,988

Divide by 175 the heat furnished per hour by one square foot of the indirect stack, and we find the radiation required is 326 square feet. The stack installed to heat these rooms contains 330 square feet.

Ratio—1 : 22½ cu. ft. air.

In room B the air will change six times per hour, as there is an aspirating flue in the room. Here we have:

Glass	70 x 72	=	5,040
Wall	150 x 22	=	3,300
Cu. ft. air	1,960 x 8.4	=	16,464

Total heat required per hour in B. T. U. 24,804

Divide by 175 = 142 sq. ft. This stack installed to heat this room contains 150 sq. ft.

ROOM E.

Glass	30 x 72	=	2,150
Wall	200 x 22	=	4,000
Cu. ft. air	1,320 x 1.4	=	1,850

Total heat required per hour in B. T. U. 8,000

Divide by 150 for direct = 53 sq. ft. radiation.

Ratio—1 : 25 cu. ft. air.

There are only 37 square feet in the radiation installed, which was used for a plate warmer, the room being warmed by the range.

On second floor.

Room F. Air change twice per hour.

Glass	70 x 72	=	5,040
Wall	140 x 22	=	3,008
Ceiling	288 x 9	=	2,600
Cu. ft. air	2,740 x 2.8	=	7,700

Total heat required per hour in B. T. U. 18,420

Divide by 150 = 123 sq. ft. radiation.

Ratio—1 : 22 cu. ft. air.

Radiation installed—127 sq. ft.

Room G. Air changed twice per hour.

Glass	20 x 72	=	1,440
Wall	20 x 22	=	404
Ceiling	154 x 9	=	1,390
Cu. ft. air	1,460 x 2.8	=	4,088

Total heat required per hour in B. T. U. 7,358

Divide by 150 = 49 sq ft. radiation.

Ratio—1 : 30 cu. ft. air.

Radiation installed 52 sq. ft.

Room K. One change of air per hour.

Glass	30 x 72	=	2,160
Wall	100 x 22	=	2,200
Ceiling	160 x 9	=	1,440
Cu. ft. air	1,410 x 1.4	=	1,990

Total heat required per hour in B. T. U. 7,790

Divide by 150 = 52 sq. ft. radiation.

Ratio—1 : 27½ cu. ft. air.

Radiation installed 48 sq ft.

Room M. Air changed twice per hour.

Glass	40 x 72	=	2,880
Wall	110 x 22	=	2,410
Ceiling	160 x 9	=	1,440
Cu. ft. air	1,420 x 2.8	=	4,000

Total heat required per hour in B. T. U. 10,730

Divide by 150 = 72 sq. ft. radiation.

Ratio—1 : 20 cu. ft. air.

Radiation installed 72 sq. ft.

Our object in publishing the plans of this house and describing it at length is to give a practical illustration of how required radiation may be computed from heat transmission and transference.

If the heating contractor, who has been guessing more or less on his work, and making mistakes, will take the trouble to give this method of figuring radiation a little serious thought, he will soon be able to adapt the system to any condition which he may meet in his business, and after installing a few jobs figured in this way, he will be so pleased with the results that he will never want to go back to the old methods.

CHAPTER XX.

HEATING A FACTORY BUILDING WITH STEAM WITH DIFFERENT TEMPERATURES ON DIFFERENT BOILERS.

THE subject of this chapter is the heating of a factory building where different conditions prevail on different floors. The construction is cement blocks 12 inches thick, with a 4-inch air space, which should be a poor conductor of heat.

In this building, the wareroom, which occupies all of the first floor except the offices, is to be kept at a temperature of 50 degrees when the outside temperature is at zero. The offices on this floor are to be kept at 70 degrees.

Owing to the frequency with which the doors are opened in the warehouse and shipping room, it is calculated the air will change at least twice per hour, and on this supposition the quantity of radiation required is computed.

On the second and third floors provision is made by ventilators in the roof for changing the air twice per hour, and the air which enters is taken in through registers on the side walls under the heating coils, which makes a very good and cheap arrangement for ventilation.

In computing the radiation required for a building of this kind, it is imperative that the heating contractor should have a knowledge of the law of heat transmission if he expects to get the proper quantity and distribution of the radiating surface. If it is attempted to figure after the method adopted by the great majority of heating contractors, the probability is that the first floor would have too much radiation and the third floor would not have enough.

A reference to the plans shows that the building is heated by 1¼-inch pipe coils, with the exception of the office. These pipe coils are placed in single rows under the windows, where they will be at their highest efficiency, that is, they will condense more steam per square foot per hour in that position than in any other. The pipe coils on the first floor will condense more steam per hour than those on the second and third floors, because they are standing in cooler air, and the difference in temperature between the steam in the coils and the surrounding media is greater.

We will place the emission of heat per square foot per hour for the first floor coils at 350 B. T. U.; for the radiators on the first floor, which stand in the office, at 240 B. T. U.; for the pipe coils on the second and third floors at 300 B. T. U.

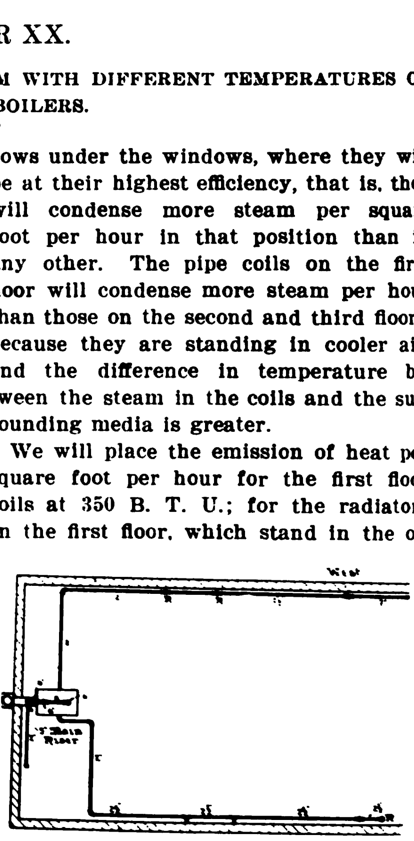

FIG. 93 -BASEMENT PLAN IN HALF

The multipliers in this case are the same as were explained and shown in a table in a former article.

In computing this radiation we would proceed as follows:

First floor: Temperature 50 deg., air to be changed twice per hour.

Glass	420 x 52	=	21.840
Wall	4.020 x 16	=	64.320
Cu. ft. air	84.600 x 2	=	169.200
Loss of heat in B. T. U. per hour....			255,360

Divide by 350 = 730 sq. ft. radiation.

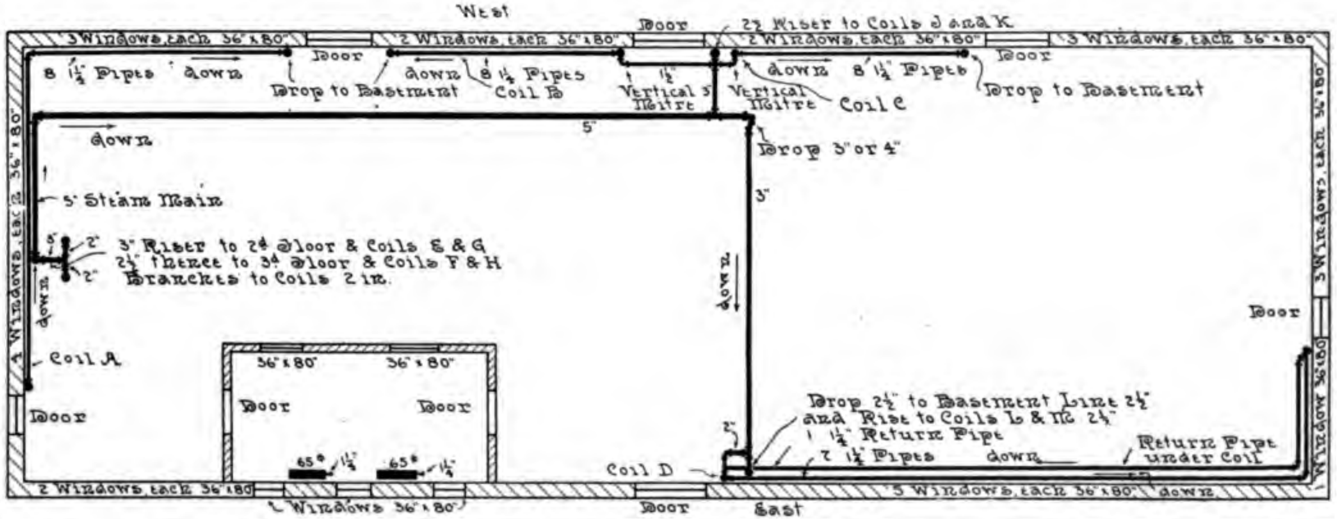

FIG. 94—FIRST FLOOR PLAN SHOWING ARRANGEMENT OF HEATING SYSTEM IN A FACTORY BUILDING WHERE DIFFERENT CONDITIONS PREVAIL ON EACH FLOOR

Office: Temperature 70 deg, air to be changed twice per hour.

Glass outside	60 x 72	=	4,320
Glass, inside	40 x 20	=	800
Outside wall	300 x 22	=	6,600
Inside wall	680 x 7	=	4,760
Cu. ft. air	5,400 x 2.8	=	15,120

Loss of heat in B. T. U. per hour.... 31,600

Divide by 240 = 130 sq. ft. radiation.

Second floor: Temperature 70 deg., air to be changed twice per hour.

Glass	1,280 x 72	=	92,160
Wall	3,520 x 22	=	77,440
Cu. ft. air	90,000 x 2.8	=	252,000

Loss of heat in B. T. U. per hour.... 421,600

Divide by 300 = 1,400 sq. ft. radiation.

Third floor: Temperature 70 deg., air to be changed twice per hour.

Glass	1,280 x 72	=	92,160
Wall	3,520 x 22	=	77,440
Roof	7,500 x 22	=	165,000
Cu. ft. air	90,000 x 2.8	=	252,000

Loss of heat in B. T. U. per hour.... 586,600

Divide by 300 = 1,950 sq. ft. radiation.

The total amount of radiation and coils is 4,210 square feet. It is usual to allow 20 per cent. of the steam radiation for the mains, but in this case, as the coils are made so that they will return their own condensation, there is very little additional pipe and fittings. We may call it, however, 10 per cent., or 420 feet, and so we have to provide boiler power for 4,600 feet of radiation. As a portion of this radiation, however, stands in a temperature below 70 degrees, and as all of the radiation is placed where it will be of the highest efficiency, we will be safe enough in selecting a boiler that will have a capacity of not less than 6,000 square feet of radiation.

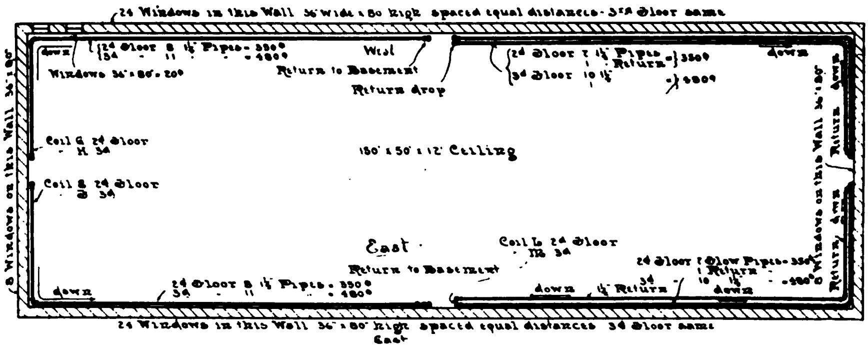
24 Windows in this Wall 36" wide x 80" high spaced equal distances - 3rd floor same
2d floor 8 1¼" Pipes - 330°
3d " " " - 480°
down
Windows 36" x 80" - 20°
West
Return to Basement
Return drop
2d floor 7 1¼" Pipes } 330°
Return
3d floor 10 1¼" } 480°
down
8 Windows on this Wall 36" x 80"
Coil G 2d floor
H 3d
Coil E 2d floor
D 3d
150' x 50' x 12' Ceiling
East
Coil L 2d floor
M 3d
Return to Basement
2d floor 8 1¼" Pipes - 330°
3d " " " - 480°
down
1¼" Return
down
2d floor 7 flow Pipes - 330°
1 Return
3d 10 1¼" - 480°
down
Windows on this Wall 36" x 80"
Return down
24 Windows in this Wall 36" x 80" high spaced equal distances 3d floor same
East

FIG. 95—SHOWING FLOOR PLAN OF SECOND AND THIRD FLOORS IN A FACTORY BUILDING

To do this work properly and easily we would select a cast-iron sectional boiler, having 28 square feet of grate surface and 400 square feet of heating surface. To do the most effective work, about 60 per cent. of the heating surface should be direct, or exposed to the direct action of the fire.

The stack for this boiler, if not built of brick, should be a round steel stack, 20 inches in diameter and 60 feet high, made of No. 12 W. G. sheets.

Fig. 98 shows the basement plan; Fig. 94 the first floor, and Fig. 95 represents the second and third floors, which are both alike, except that the third floor, having the additional cooling surface of the roof, requires more radiation and the amount of radiation required by this floor is marked on the second floor plan.

Turning to the basement plan, we show two 6-inch pipes rising from the steam dome of the boiler. These are carried in one 6-inch pipe to the foot of the main riser, where the size is reduced to 5 inches. This 5-inch riser is shown in the elevation plan, Fig. 96. This main steam pipe is carried along the ceiling of the first floor to about the center of the building. At this point there is placed a tee 5 x 5 x 3. Out of the 3-inch opening a branch is run to the west side of the building, where it rises 2½ inches to the third floor, and from this 2½-inch riser are fed coils "J" on second floor and "K" on third floor. The coils are fed 2½ inches. The steam in these coils runs down hill to the north end of the building, where the condensation drops to a single return pipe, which is brought back to the north, at which the steam enters the coil, and from there is dropped to the return in the basement.

From the ends of the 5-inch tee, the main is continued 5 inches for about 2 feet. At that point is placed a 5 x 3 ell, which looks down. A nipple is placed between that and a 3-inch elbow and a 3-inch pipe is carried across the ceiling to the east side of the building. At this point it rises 2½ inches to feed coil L, on second floor and M on the third floor. The return from these coils comes back to the place of starting the same as they do on the west side of the building, and are there dropped to the return in basement. This return is made 2½ inches in diameter, because from it is fed the two radiators in the office on the first floor. It continues 2½ inches until it passes the radiators, where it may be reduced by a reducing ell to 2 inches and carried thence to the boiler.

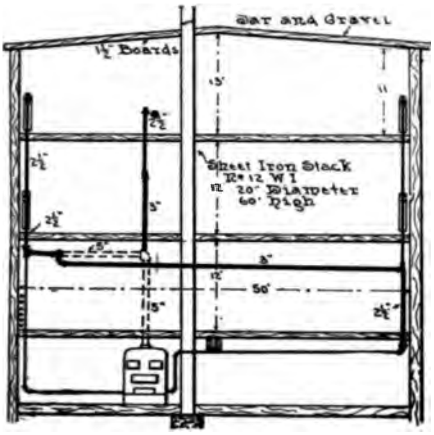

FIG. 96—ELEVATION. 5-INCH RISER IS SHOWN

The expansion of the corner coils will principally be in the corners and at that point, instead of using the ordinary hook plate, there should be an expansion plate hanger, which has straight rests on it instead of curved. This prevents any binding at that point and the coil will not buckle.

Coils "B" and "C" on the first floor do not turn the corner, and they must, therefore, be made with a vertical miter and fed at the top. These coils are both fed off the 3-inch branch which comes from the steam main. One and one-half inches will be large enough to feed them. The coils "E," "F," "G" and "H" are all fed directly from the top of the main riser where it leaves the boiler, and the steam in these coils all runs to the further end, and there the return, 1¼ inches in size, drops to the basement and is there connected to the return.

The main return on the west side of the building is below the water line. On the east side of the building it is kept well above the water until the two office radiators are taken off. After that it may drop below the water line if desired.

The wall strips, to which are attached the hook plates for suspending the coils, should be made of good white pine, 1½ inches thick. The brick or cement is then drilled at one or two points and lag screws with expansion sleeves, should be used to hold them in place. The hole is drilled in the cement or brick with a piece of pipe which is serrated on its end. The hole is made so the expansion sleeve will enter easily. When the plate is screwed to place, the sleeve is jammed so tightly into the hole that it is impossible for it to work loose. Where a hole is drilled in the wall and plugged with wood, and the wall strip fastened to these wooden plugs with wood screws, they will soon work loose and the coils are liable to tumble down. Work of this kind should be very carefully done. In making up the joint care should be taken that the threads are perfectly clean and that they are made up into the fittings so they will be tight. Instead of using right and left couplings, which can rarely be depended upon for a tight joint, it is better to use in the corners right and left ells.

The return pipe which comes back under the long coils should have a greater pitch than the coil itself, as it carries the condensed water of all the pipes and it will be necessary to give it a strong pitch so it will clear itself of water easily.

The fuel for operating a job of this kind may be hard coal, egg size, or any good caking soft coal, or a mixture of soft coal and coke, which makes an excellent fuel.

The mains for this job could all be run in the basement, one branch on each side of the building, but there would be nothing gained by doing so. On the contrary, the cost of pipe and fitting would be greatly increased, as would also the condensation and fuel demand.

CHAPTER XXI.

WATER HEATING APPARATUS IN AN APARTMENT BUILDING—AN EXPENSIVE YET CRUDE INSTALLATION—SKETCHES SHOWING IMPROVED METHODS.

We present in this article basement plans and typical floor plans of a three-story and basement apartment building located in Western New York. This building was erected three years ago and in it there is installed a hot water heating apparatus. Plan "A," Figs. 97 and 98, show the apparatus as it was installed and as it is to-day.

The radiation in the different rooms is as follows:

	Sq. ft.
Basement, 3 radiators 40', 30', 40'	110
6 Parlors, 6 radiators 100' each	600
6 Dining rooms, 6 radiators 75' each	450
6 Chambers No. 1, 6 radiators 60' each	360
6 Chambers No. 2, 6 radiators 65' each	390
6 Kitchens, 6 radiators 50' each	300
6 Baths, 6 radiators 20' each	120
3 Hall, 3 radiators 100', 80', 60'	240
Total, 42 radiators, containing	2,570
Add for piping	700
Boiler load	3,270

The sizes of valves are as follows:

6 Parlor radiators have valves	1½ in.
6 Dining room radiators have valves	1¼ in.
12 Chamber radiators have valves	1¼ in.
6 Kitchen radiators have valves	1¼ in.
3 Basement radiators have valves	1¼ in.
1 Hall radiator has valves	1½ in.
2 Hall radiators have valves	1¼ in.
3 Bath radiators have valves	1 in.

The boiler selected for this job has a catalog rating of 2,500 feet, notwithstanding the boiler load is 3,270 feet. However, the boiler is large enough to heat the building with the water ranging from 140 to 160 degrees.

The steamfitter who installed this work had great difficulty in getting some of the radiators to circulate and he was put to a good deal of expense on this account. This was largely due to the proportioning of the piping. It will be noticed by looking at the sizes of the valves used that the radiators were connected up to the standard tapping, irrespective of what floor they occupied or how far they were from the boiler.

An estimate of the cost of the work complete is about $1,500, as follows:

Boiler rated 2,500 ft	$280.00
2,570 sq. ft. radiation at 20c	514.00
42 Radiator valves and ells at $1.80	75.60
Pipe and fittings	200.00
42 days' labor, man and helper at $5	210.00
30-gallon expansion tank	10.00
Altitude gauge	1.50
Thermometer	1.50
Decorating	50.00
Pipe and boiler covering	125.00
Incidentals	25.00
Net cost	$1,492.60

The contract price was $1,380. The cost to the steamfitter before he got the job to work so he could get his money was over $1,600.

This job was figured wholly from cubic contents and no difference was made between the first, second and third floors. When the radiators on a job of this kind are all fed from the basement, the first and second floors require less radiation than the third floor, for the reason that the radiation of the third floor does not receive water as hot as that on the first and second floors, and, furthermore, additional heat is lost through the ceiling and roof.

The risers and radiator valves in plan "A" are too large to almost every room. A reference to Fig. 97 shows that there are four radiators to be heated in the basement. The return from these radiators runs back to the boiler under the concrete and there rises to the boiler re-

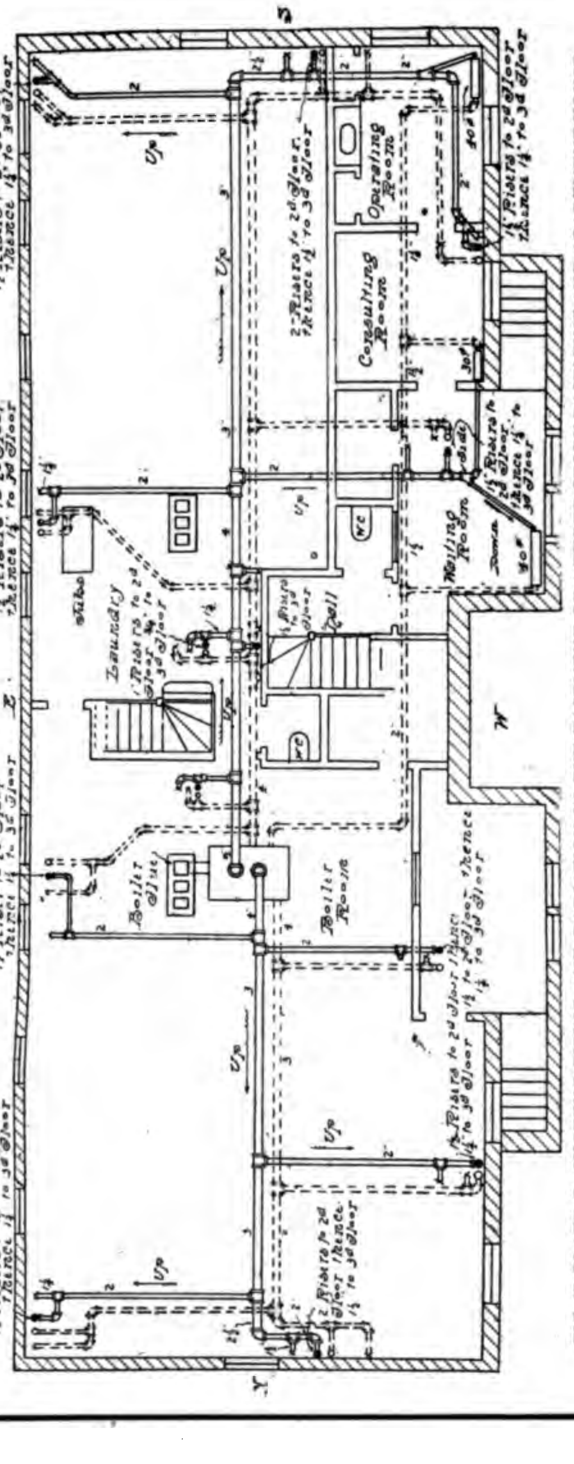

FIG. 97, PLATE C—SHOWING PIPING AND RADIATION IN THE BASEMENT OF A THREE-STORY BASEMENT AND APARTMENT HOUSE
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turn about 24 inches. These radiators are fed at the top directly from a branch leading from the main flow pipe. The steamfitting contractor has never been able to make these radiators effective. Under strong fires they will heat about one-third the way down and gas stoves have to be used in those basement rooms.

Plan "B," Figs. 99 and 100, are plans of the same building and here the amount of radiation required is figured from heat transmission, as follows:

	Loss of heat per hour in B.T.U.
Parlors 12 x 19 x 10—	
Cubic feet air 2,280 × 1.4 =......	3,200
Square feet glass 51 × 72 =......	3,680
Square feet wall 259 × 22 =......	5,700
Divide by 150.	12,580
Radiation required, 84 square feet.	
Dining rooms 10½ x 16 x 10—	
Cubic feet air 1,680 × 1.4 =......	2,360
Square feet glass 34 × 72 =......	2,450
Square feet wall 231 × 22 =......	5,100
Divide by 150.	9,910
Radiation required, 66 square feet.	
Chamber No. 1, 14½ x 10 x 10—	
Cubic feet air 1,450 × 1.4 =......	2,030
Square feet glass 17 × 72 =......	1,220
Square feet wall 83 × 22 =......	1,820
Divide by 150.	5,070
Radiation required, 34 square feet.	
Chamber No. 2, 12 x 13 x 10—	
Cubic feet air 1,560 × 1.4 =......	2,190
Square feet glass 17 × 72 =......	1,220
Square feet wall 113 × 22 =......	2,500
Divide by 150.	5,910
Radiation required, 40 square feet.	
Kitchen 10 x 11 x 10—	
Cubic feet air 1,100 × 1.4 =......	1,540
Square feet glass 22 × 72 =......	1,585
Square feet wall 78 × 22 =......	1,720
Divide by 150.	4,845
Radiation required, 32 square feet.	

Bath rooms—no exposure.

Radiation required, 10 square feet.

Lower hall—no exposure.

Radiation required, 80 square feet.

Second floor hall—

No radiation required.

Third floor hall, to compensate for loss of heat through roof—

Radiation required, 50 square feet.

Total, 35 radiators.

This gives the total radiation 1,785 square feet, distributed in 35 radiators, as follows:

DISTRIBUTION PLAN "B."

	First Floor.	Second Floor.	Third Floor.	Sq. ft.
Basement, 25 x 25 x 15=.............				75
Parlors, each	85	85	100	540
Dining rooms, each..	65	65	75	410
No. 1 Chambers, each	30	30	35	190
No. 2 Chambers, each	35	35	40	220
Kitchens, each	35	35	40	220
Halls, each	80	0	50	130
Baths	2-inch riser			
				1,785

Number of radiators, 35.

Size of radiator valves—

Parlors, first floor, 1¼ inch; second and third floors, 1 inch. All other valves, 1 inch, except on bedroom radiators, which are ¾ inch.

The estimated cost of this job is $1,202.50, as follows:

Boiler, 2,500 feet	$280.00
1,785 square feet radiation at 20c...	357.00
35 radiator valves and ells at $1.50..	52.50
Pipe and fittings	160.00
36 days man and helper, at $5.00....	180.00
30-gallon expansion tank............	10.00
Altitude gauge	1.50

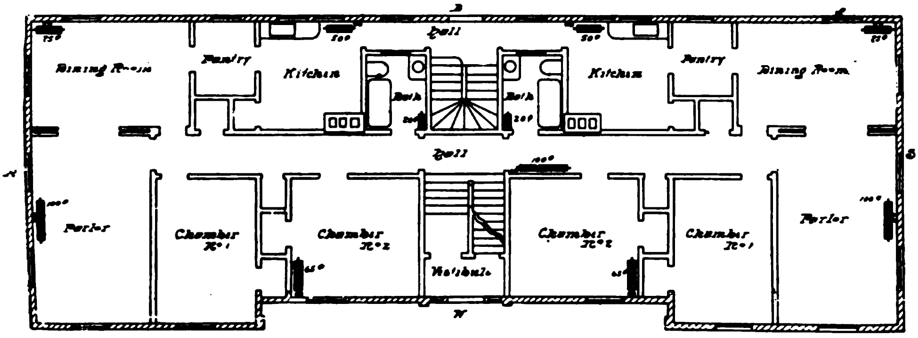

FIG. 98. PLAN G—HEATING A 3-STORY AND BASEMENT APARTMENT HOUSE, WESTERN NEW YORK

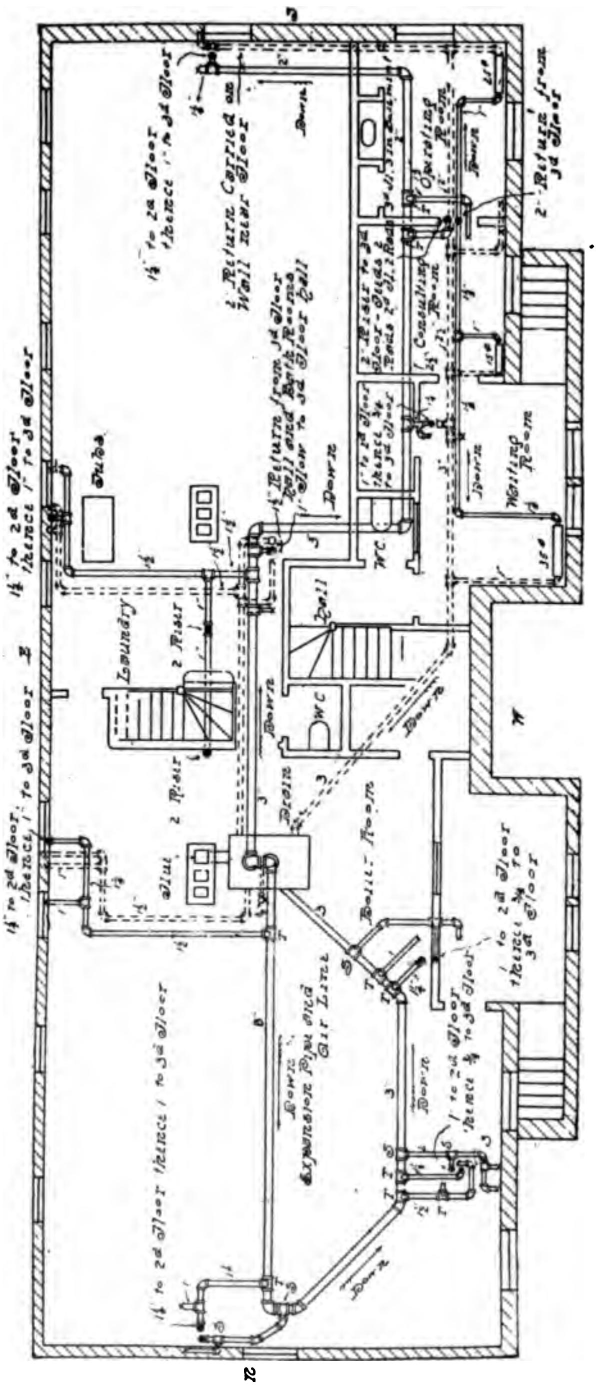

FIG. 99. PLAN B—BASEMENT PLAN. THE PIPE IS A COMBINATION OF FLOW AND RETURN AND ONE PIPE CIRCUIT

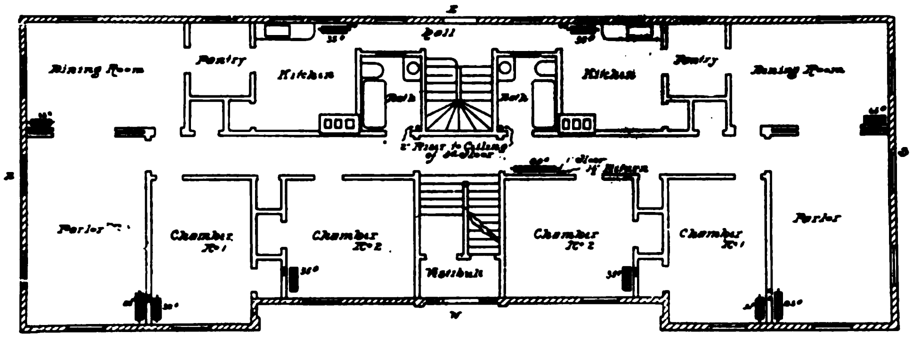

FIG. 100. PLAN B—HEATING A 3-STORY AND BASEMENT APARTMENT IN WESTERN NEW YORK

Thermometer	1.50
Decorating	35.00
Pipe and boiler covering	100.00
Incidentals	25.00
Net cost	$1,202.50

In this plan we have changed the position of the parlor and dining room radiators from the extreme outside to the inner walls. We may be criticised for doing this, but where rooms are of the size and shape of these parlors and dining rooms and the windows are fitted as tight as they ought to be, the position of the radiators in plan "B" will be satisfactory.

In the bath rooms we have eliminated the radiators and heat all bath rooms with a 2-inch riser in each. These risers run through the ceiling of the third floor. At that point they are joined together into one 1½-inch pipe, which crosses the ceiling of the hall between the joists, drops to the third floor and there connects into

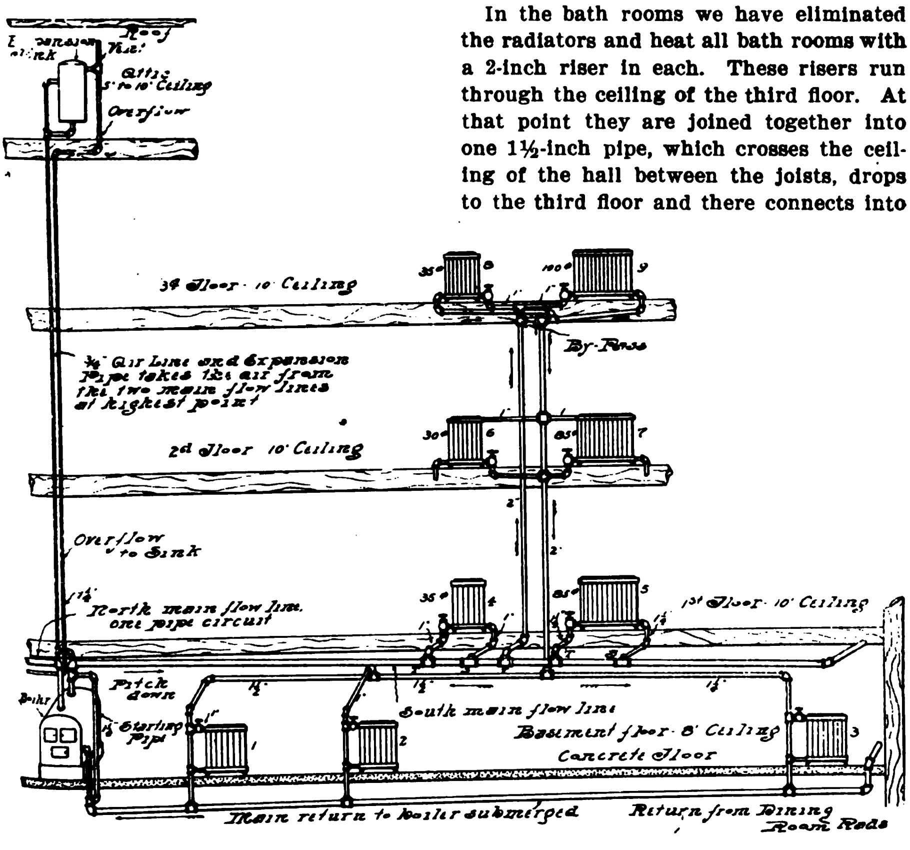

FIG. 101. PLAN B—DETAIL SHOWING THE METHOD OF FEEDING BASEMENT RADIATION

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the return of the third floor hall radiator, which is enlarged to accommodate them.

Referring to the basement plan, Fig. 99, the pipe is a combination of flow and return and one-pipe circuit. The 2-inch risers which carry the parlor and No. 1 chamber radiators, rises to the third floor where they form a loop and drop back to the basement. From the top of these risers an air pipe is carried to the expansion pipe, which relieves both risers of air. The second floor radiators are connected to the return loop top and bottom.

When this 2-inch pipe reaches the basement it divides and is connected to the basement radiators, in each case dropping through the basement floor by a by-pass into the submerged return. This submerged return carries the return water of the greater part of the radiation, as will be seen by reference to the plan.

In the north end of the building a one-pipe circuit is used, in the usual manner. The flow pipes rising from the top of the pipe and the return entering the side. By this method of piping much less pipe is required than in plan "A."

In Fig. 101 is shown in detail the method of running the 2-inch risers in plan "B," also the method of connecting the basement radiators, and at the boiler is shown a 1¼-inch pipe which is taken out of one of the flow pipe risers and drops to the bottom of the submerged return, where it rises to the boiler. This is done, as explained in a previous article, to warm and consequently lighten the water in the return pipe at this point.

The reason for carrying the 2-inch risers to the third floor and then dropping to the basement with the return loop to feed the basement radiation, is to obtain a difference in the two columns of water, which stimulates the otherwise sluggish circulation in radiators standing on the same level as the boiler. Basement radiators connected up in the manner shown in the sectional sketch, Fig. 101, will heat as well as radiators on the floor above the boiler, providing that the starting pipe is employed to lighten the return and stimulate circulation. The expansion tank in this case is connected to the two flow pipes as they leave the boilers, and this being the high point the expansion pipe acts as an air relief for all the mains and radiators in the basement.

In a future article these same floor plans are shown laid out for an overhead water job and also for a modern steam-heating apparatus, giving an opportunity to compare the different methods.

CHAPTER XXII.

WATER HEATING APPARATUS IN AN APARTMENT BUILDING—IMPROVED METHODS OF PIPING.

WE present herewith floor plans of an apartment building the same as shown in previous chapter. In these plans we show an overhead water heating apparatus. Our object in showing the plans with different styles of piping, is to give a graphic illustration of the wide difference in the cost of heating a building by different methods.

In overhead heating, as is well known, the water is carried to the attic and there distributed to the different risers which carry the radiation on the various floors. It is a system of water heating peculiarly adapted to apartment buildings, where the radiators on each floor occupy the same vertical line.

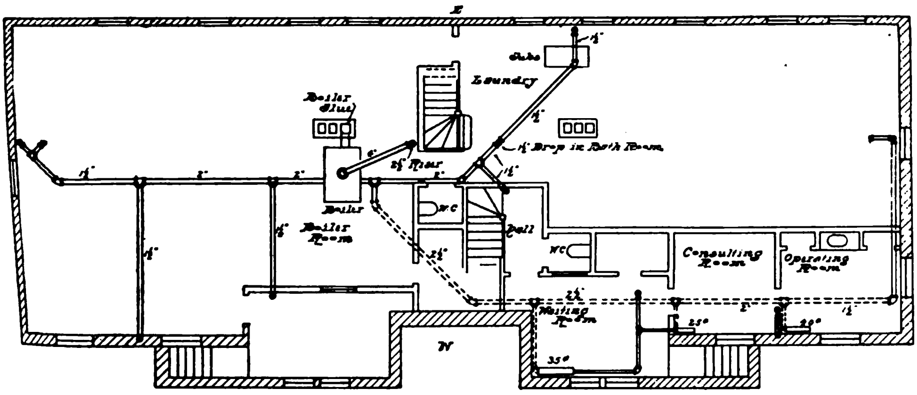

FIG. 102, PLAN C—SHOWING THE BOILER ROOM, ETC.

In drawing these plans the writer has not followed the customary pipe sizes, but has shown advanced ideas whereby a great deal of the first cost may be cut out of a heating apparatus. It is a well-known fact that there is no scientific basis in use among steam fitters for obtaining pipe sizes in either water or steam heating and it is a question whether any scientific rule can be given whereby the sizes may be just right to cover every condition, neither too large nor too small.

Comparing this plan, which we will call plan "C," with plan "A" published in our last issue, we see a very great difference in pipe sizes. It is very true that where the overhead system is employed, much smaller pipes may be used than where the main flow and return pipes are all in the basement. This is because the overhead hot water heating system produces a higher velocity of the water flowing through the pipes than it is possible to obtain with the two-pipe system in the basement.

It is a well-known fact that in district heating systems where a pump is used to force the water through the system and control the velocity, that very small pipes are necessary. A $1\frac{1}{2}$-inch pipe in such systems will often do as much work as will a 3-inch pipe in systems where there is no motive power beyond the difference in weight of the ascending and descending columns, and so we may say that any system of water heating which increases the velocity of the water through the pipes, requires correspondingly smaller pipe sizes.

In this system (plan C) the direct radiation amounts to 1,720 square feet; piping to 340 square feet, making a total of 2,060 square feet which the boiler has to care for. To carry this radiation properly we run from the boiler to the foot of the main riser with a 4-inch pipe. Here we use a 4 x 2½-inch ell, and rise to the attic with 2½-inch pipe. In the attic we again enlarge the pipe to 4 inches, and from the top of the fitting on the main riser we carry a 1-inch pipe to the expansion tank, as is shown in the sectional view, Fig. 104 A. The top of the riser is the high point from which all the air in the system accumulates and is taken care of by the expansion tank. The 4-inch main is carried a short distance across the attic floor where a 2½ x 2½ x 4-inch twin ell is used. These 2½-inch branches feed nearly all of the radiators in the building, the only exception being the drop risers for the kitchen radiators, which are on the east side of the building. For the dining room and parlor radiators we use a 1½-inch feed pipe and a separate return. As these are the principal rooms in the building we do this that there may be a more even distribution of the heat than is possible where but one pipe is used.

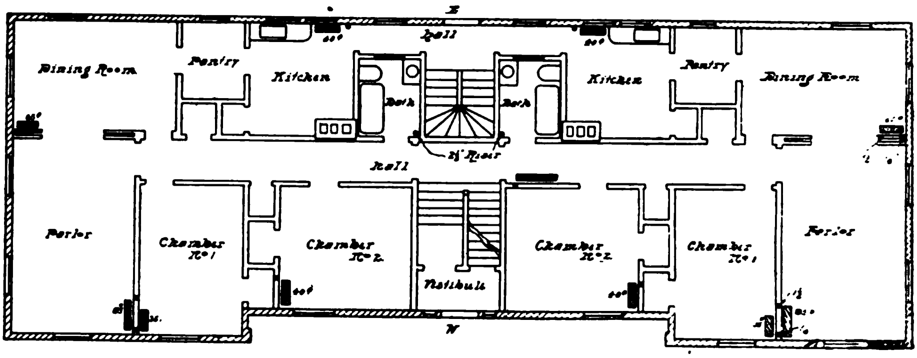

FIG. 103, PLAN C—PLOOR PLAN SHOWING THE LOCATION OF THE RADIATORS

By referring to Fig. 104 A a method of connecting the parlor and No. 1 bedroom radiators is shown, and also the method of connecting the bedroom radiators in the north end of the building to a single pipe line. The connections from the riser to the radiators should not be made rigid. In the case of the flow pipe they should be taken off the side of the riser, come through the wall, and connect with a right and left, or union ell, to the radiator. This gives a little up and down swing to the connecting pipe, whereas if the connecting arm is screwed directly into the riser, it makes a rigid joint, and requires very exact work to make the connection.

On the return end the connections are made from beneath the floor in the usual manner, the valve being used on the return instead of on the flow pipe.

The arrangement of the expansion tank is shown in Fig. 104 A. The tank used may be a 30-gallon range boiler, but it would be better to have a tank made with special tappings so the piping may be connected as shown in the sketch.

On the three-quarter overflow pipe is used a lever safety valve set at 10 pounds. This three-quarter overflow empties into a galvanized iron drip pan, which is placed immediately below the safety valve, so that any escape of water when the valve is opened may fall into the pan. From the bottom of this drip pan is taken a 1¼ overflow pipe, which is carried to the boiler room and there discharged into a funnel connected to the sewer and furnished with a trap. As the

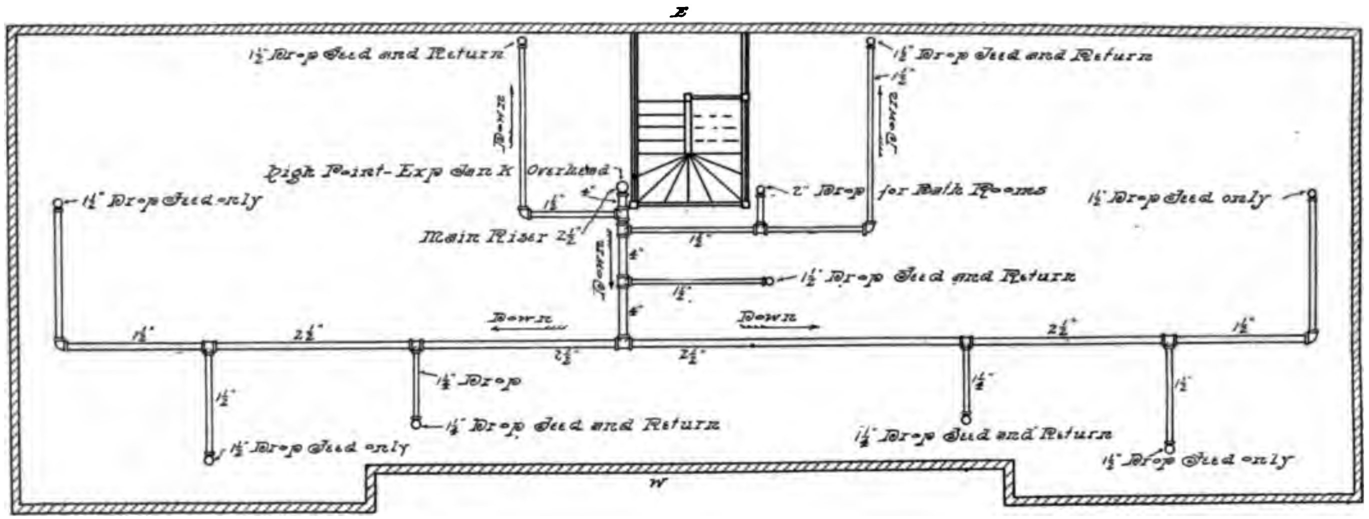

FIG. 104, PLAN C OVERHEAD WATER HEATING. PIPING ON ATTIC FLOOR JOISTS. ALL BRANCHES OUT OF SIDE water in the trap might dry out during the summer months, the funnel pipe is fitted with a plug cock, which may be closed when the apparatus is not in use. From the end of the lever of the safety valve a small chain or cord is carried overhead and through one or more pulleys, and is then brought to the boiler room.

In filling the apparatus the operator opens the supply valve for filling the boiler, and pulls down on the wire or chain which is attached to the lever of the safety valve. This permits the air to rise to the expansion tank and be discharged through a ¾ overflow pipe into the attic. As soon as the tank is filled the water will flow down to the boiler room through the 1¼ overflow, and give notice to the operator that the apparatus is full of water. After the water has been heated to the normal temperature, the safety valve may be again lifted to allow any excess of water and air to be thrown off.

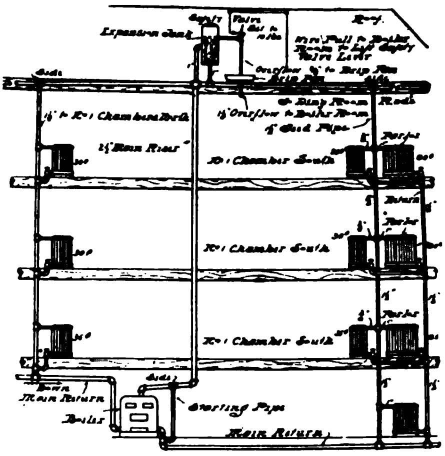

FIG. 104 A, PLAN C – SECTIONAL VIEW OF OVERHEAD WATER HEATING

In some cases a vacuum valve is fitted on the tank to permit the air to enter the tank after the water and air has been discharged, but with this device it is not necessary.

In the basement, the radiators in the doctor's offices are connected up as shown in Fig. 104 A.

It is usual in apportioning the radiators for overhead water heating to place the smallest amount of radiation on the upper floor and gradually increase until the lower floor is reached, where the greatest amount of radiation is used. In this plan we have increased the radiation on the first floor, while the second and third floors have each the same quantity. While it is true that the radiators of the third floor will receive water at a higher temperature than will those on the second floor, yet the cooling effect of the roof will just about compensate for this difference.

To do this work properly we have selected a square boiler with vertical sections, the capacity of which is 2,100 square feet. The distribution of the radiation is as follows:

	1st Floor.	2d Floor.	3d Floor.
Parlors	85	80	80
Dining rooms	65	60	60
Kitchens	40	35	35
No. 1 chambers	35	30	30
No. 2 chambers	40	35	35
Hall	80	0	50
Basement	100		
Total	1720 sq. ft. of radiation		
Piping	340		
Boiler load	2060 sq. ft.		

The actual cost of this apparatus is as follows:

Boiler, 2100 ft.	$225.00
1,720 sq. ft. radiation	344.00
35 valves and ells at $1.25	43.75
Pipe and fittings	120.00
30 days—man and helper—$5.00	150.00
30-gallon expansion tank	10.00
Alt. gauge	1.50
Thermometer	1.50
Decorating radiators	30.00
Pipe and boiler covering	75.00
Incidentals	25.0
Actual cost	$1,023.7

The prices shown above will var somewhat in different localities, but w believe the cost as shown above to be fair average. Three of the bath room are warmed by the 2½-inch main rise the other three by a 2-inch drop pipe connected to the main distributing pipe i the attic. A portion of these risers ma be covered if the bath rooms are overheated.

CHAPTER XXIII.

STEAM HEATING APPARATUS IN AN APARTMENT BUILDING, SHOWING COMPARATIVE COST OF STEAM AND WATER HEATING.

IN Chapter XXI. we presented floor plans of an apartment building where a hot water heating apparatus had been installed for several years, and which had not been fully satisfactory, owing to the rather crude method of proportioning the piping. In the same article we showed how the radiation could be reduced in quantity, and an improved method of pipe sizes for basement piping.

In Chapter XXII. an overhead system of hot water heating is shown, applied to this same building. In the present article we reproduce the basement and first floor plans of the same apartment building, piped for low-pressure steam heating. The quantity and distribution of radiation is as follows:

DISTRIBUTION OF RADIATION—PLAN D.

		1st Floor.	2d Floor.	3d Floor.
Parlors	sq. ft.	50	50	55
Dining rooms	"	40	40	45
No. 1 bed rooms	"	20	20	20
No. 2 bed rooms	"	25	25	25
Kitchens	"	20	20	20
Hall	"	50	..	30

Bath rooms 1½-inch risers in each tier; basement rooms, overhead coils.

Totals.

		1,030
6 parlors	sq. ft.	310
6 dining rooms	"	250
6 No. 1 chambers	"	120
6 No. 2 chambers	"	150
6 kitchens	"	120
2 halls	"	80
Basement coils	sq. ft.	45
Piping	"	200
Boiler load	sq. ft.	1,275

In this plan the radiation is slightly increased on the third floor to compensate for the cooling effect of the attic ceiling and roof. In the basement the three doctor's offices are warned by 1-inch return bend coils placed on the ceiling. These coils feed from the top of the main, and the condensation is dripped into the main return, which is under the floor. The bath rooms are warmed by a 1½-inch riser on each tier, which runs from the basement to the ceiling of the third floor bath room. An air valve is attached to these risers on the third floor. These bath rooms being on the inside of the house, require very little heat, and to place radiators in them would be a needless expense.

A radiator is placed in the first floor hall, and one on the third floor, there being no necessity of radiators in second floor hall. The estimated cost of this steam heating apparatus is as follows:

COST OF STEAM HEATING JOB, PLAN D.

Boiler, 1,500 ft. capacity	$290.00
1,030 sq. ft. radiation, 20c	206.00
Pipe and fittings	100.00
32 radiator valves and air valves, $1.50	48.00
20 days' labor, man and helper	100.00
Decorating	20.00
Pipe and boiler covering	60.00
Incidentals	25.00
Net cost	$849.00

The pipe sizes shown on the basement plan are probably smaller than would be attemped by the average steam fitter, but they are of ample size and will do the work just as well as though the mains were 2½ or 3 inches in diameter.

There are two lines of pipe, the one running to the south end of the building, which carries 555 square feet of radiation; and the circuit on the north side, which carries 475 feet.

The steam mains rise from the boiler the full size of the tapping, which is 3

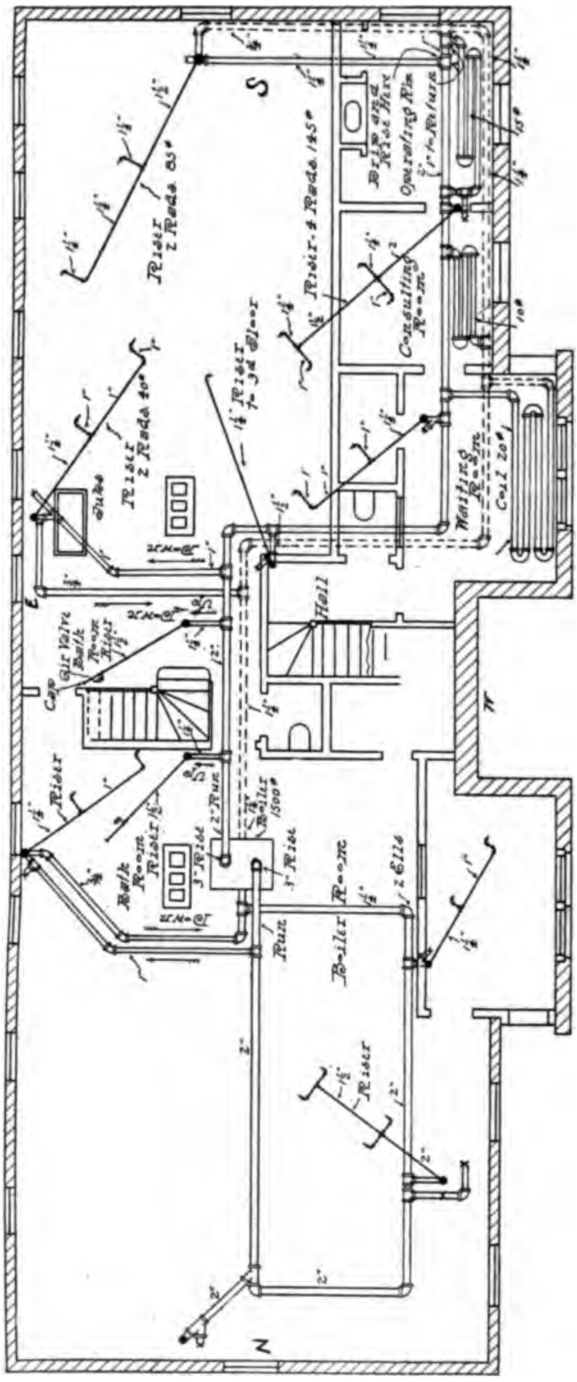

FIG. 105.-PLAN D—BASEMENT PLAN OF LOW PRESSURE STEAM HEATING IN AN APARTMENT HOUSE

inches, and at the top of this riser is placed a reducing elbow 3 x 2 inches. The common practice would be to bush the 3-inch tappings and rise from the boiler 2 inches, which practice might result in carrying water out with the steam, and cause a great deal of annoyance.

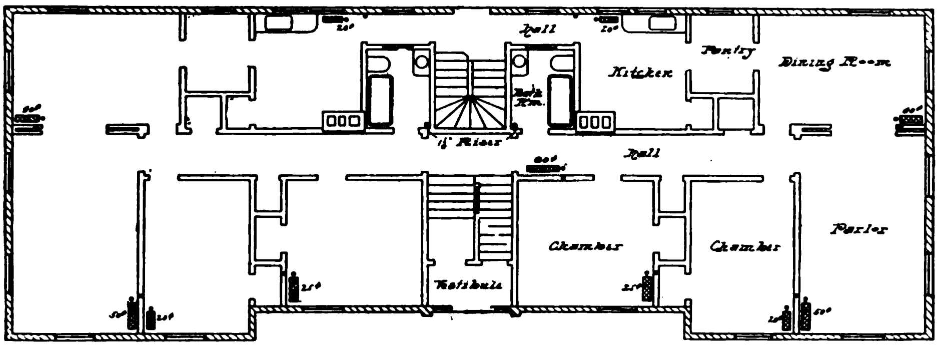

FIG. 106, PLAN D—SHOWING THE LOCATION OF RADIATORS AND RISERS

With the amount of surface attached to the 2-inch steam supplies, as is shown in this plan, the velocity of the steam through the 2-inch main at 2 pounds pressure would be 36 feet per second, and if this 2-inch pipe were connected direct to the steam dome of the boiler, the steam would enter the pipe at this same velocity, viz., 36 feet per second. By increasing the risers from the steam dome to 3 inches, we reduce the initial velocity to 16 feet per second, which will cause the boiler to work steadily.

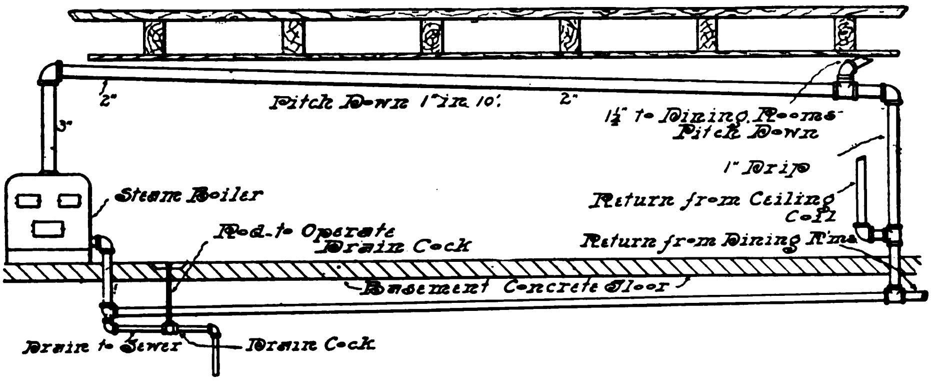

FIG. 107, PLAN D—LOW PRESSURE HEATING. THE BOILER AND CONNECTIONS

Referring to the south side of the building, the 2-inch line is carried pitching downward to point marked "A." At this point the pipe is dripped into the underground return, and from the top of the tee a branch rises and is carried pitching downward to the dining room radiators. See sketch, Fig. 105.

The return for the south end of the building is carried back to the boiler under the floor for the convenience of dripping the coils in the doctor's offices, which would otherwise have to be trapped to prevent the steam entering the returns. The returns from the kitchen radiators are brought back overhead until they reach the return to which they are connected below the water line.

The boiler load in this apparatus aggregates 1,275 square feet of condensing surface, and for this we would select a boiler that would maintain 2 pounds pressure in the entire plant for eight continuous hours without attention. A vertical sectional boiler would be the best to use for this installation, of the following dimensions: Square feet of grate, 7.5; square feet of heating surface, 100; hard coal fuel capacity, 500 pounds.

This boiler will take care of the radiation running at a moderate rate of combustion, and with a strong fire will generate steam very rapidly.

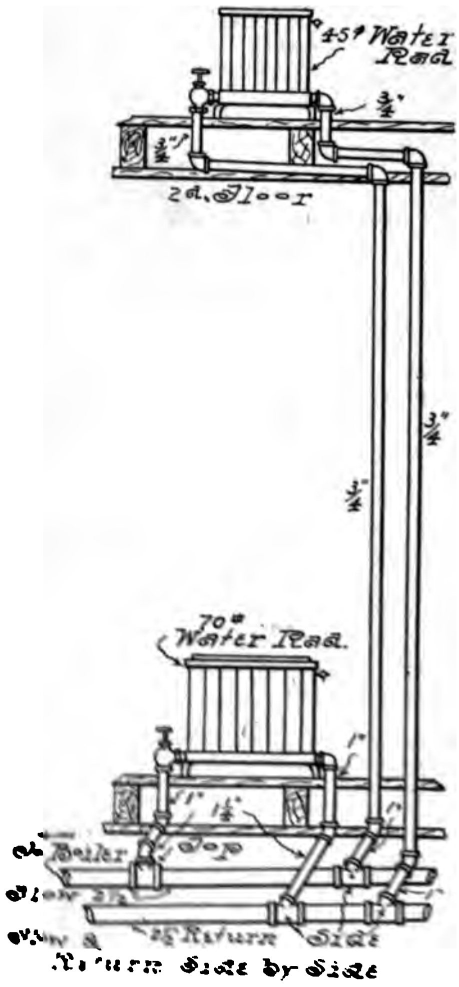

FIG. 68. HOT WATER RADIATOR CONNECTION

The cost of heating this apartment building by the four different systems is as follows: Plan A, water, basement piping, $1,500; plan B, water, improved piping, $1,200; plan C, water, overhead piping, $1,024; plan D, steam, $849.

Supposing four contractors, A, B, C and D, corresponding to the lettering of the different systems, are asked to submit bids for heating this apartment building. A adds 10 per cent. to plan A, and bids $1,650; B adds 20 per cent to plan B, and bids $1,440; C adds 25 per cent. to plan C, and bids $1,280; D adds 30 per cent. to plan D, and bids $1,100.

Possibly the owner will not consider steam, so he lets the job to C for $1,280, which is less than A's first cost. This simple illustration will help to explain why some men can do this kind of work for less money than others and be prosperous.

The writer is thoroughly convinced that thousands of dollars are annually thrown away in unnecessary pipe sizes for both steam and water heating, more particularly in steam heating.

In a steam pipe, where it is necessary for the steam and water of condensation to move in opposite directions, the pipe sizes in use at the present time may not be too large, but for main steam pipes or branches where the steam and water flow together, and for return pipes, the sizes in general use throughout the country are much larger than is necessary. Large pipe means large fittings, more labor, and more cost for covering, in addition to the increased cost of the pipe only.

The standard tappings adopted by manufacturers for steam radiators are about right, more especially for one-pipe work. We believe that for two-pipe work the tappings could be to good advantage materially reduced in size. The standard tappings for hot water radiators are entirely too large, and the fitter who uses the full sized tappings in hot water radiation will have all kinds of trouble through imperfect circulation. For example: A water radiator containing 70 feet may be placed on the first floor, and immediately above it on the second floor a radiator containing 45 feet. The standard tapping for both of these radiators is 1¼ inches. Now if a 1¼-inch riser is run to the 45-foot radiator on the second floor, the hot water will work through that radiator, come down the return, enter the return pipe and pass into the 70-foot radiator on the lower floor through the return, before the circulation from the supply pipe has worked through the radiator. These two columns of water meet in the radiator and circulation is at a standstill. If these radiators should stand near the boiler where the circulation is active, the radiator on the first floor should have a 1¼-inch pipe carried to it from the main, on the end of which should be placed a 1¼ x 1-inch ell, the radiator being connected by a 1-inch valve. The 45-foot radiator on the second floor should have a 1-inch branch run out to the foot of the riser, which should be ¾ inch, and the radiator should be connected with a ¾-inch valve. See sketch, Fig. 108.

The radiation for this apartment building is figured for the Middle States, where it is usual to provide for a temperature difference of 70 degrees Fahrenheit between external and internal.

Where the temperature difference is 50 degrees, as in some parts of the South, 30 per cent. less radiation will be sufficient. In the Northwest, where 20 degrees below is the usual outdoor temperature, 30 per cent. must be added. The proportions would be as follows:

	Southern States.	Middle States.	Northwest.
Internal temperature, deg.	70	70	70
External temperature, deg.	20	0	—20
Tempt. difference, deg.....	50	70	90
Water radiation, sq. ft....	1200	1700	2200
Steam radiation, sq. ft....	700	1000	1300

CHAPTER XXIV.

A ONE-PIPE STEAM HEATING APPARATUS WITH SUBMERGED RETURN.

WE enclose a sketch of a steam job just installed by us and ask you to give your expert opinion on the piping. You will observe it is the one-pipe system with wet return, also that we have used four three-way ells—one, the first one, a 2-inch x 2-inch x 2-inch on nipple out of boiler, the others, 2-inch x 2-inch x 1¼ inch, to radiators. We did this in order to get around brick pillars and chimney without cutting through them. The rest of the branches were taken off with tees and 40-

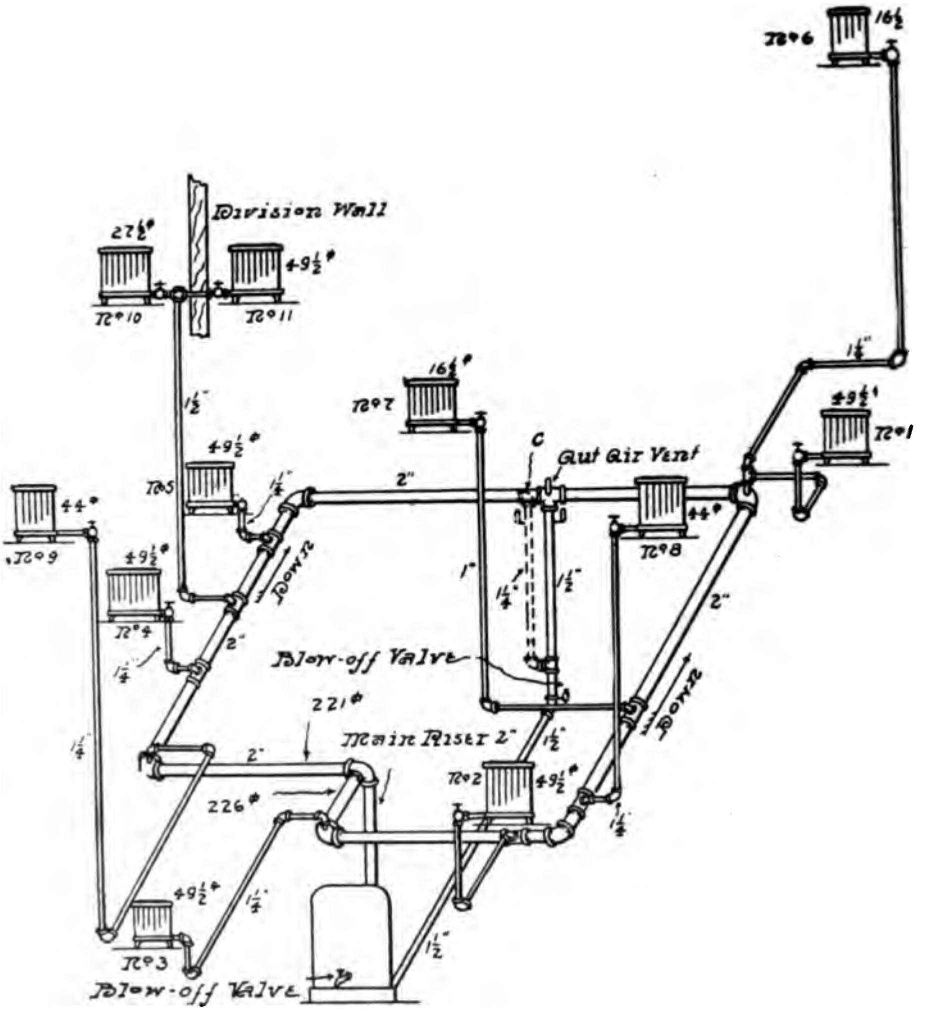

FIG. 109—ISOMETRIC VIEW OF BOILER PIPING AND RADIATION.

degree ells. The mains all slope away from boiler at a good pitch and the laterals have a pitch of about 3 inches to the foot—the return slopes toward boiler.

In the 1½-inch riser you will note we have placed a cross with a plug in top—this we did to accommodate a radiator for a room in third story when owner desires it. The valves on 1½-inch riser are "gate," straightway, in order to relieve all condensation.

SLEMMER & SON.

Sketch "A" of the two sketches mentioned by our subscriber is an isometric view of the boiler, piping and radiation. The three-way ell shown at the boiler is somewhat unusual in steam fitting, but there is no objection to using it any more than there is in using a cross, under certain conditions.

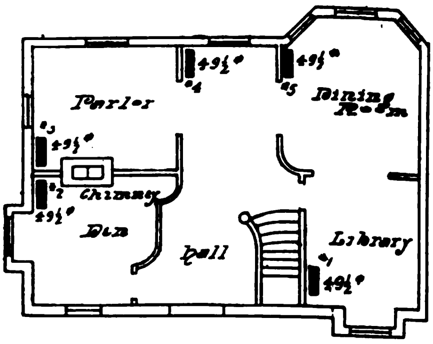

FIG. 110, SKETCH B—THE FIRST FLOOR PLAN

The pipe in this job is certainly of sufficient size to do the work without noise. Each of the mains might have been 1½ inches without lowering the efficiency of the apparatus in any particular.

Where the pipes join at "C" and drop below the water line it is good practice to drop one pipe from each main and join them below the water line, as is shown by dotted lines. In that case each drop should have an automatic air vent.

We note that the main riser from the boiler is 2 inches, and out of this is taken the two 2-inch mains. This is wrong, both in theory and practice, but inasmuch as a 2-inch pipe would easily carry all the radiation in this particular installation, no harm is done.

For a hot water heating job the writer would prefer a small opening out of the boiler connected into larger pipes, because of the ejector principle involved.

In steam heating jobs, however, the pipes rising from the boiler should be of greater area than the combined area of the mains, in order to obtain a low initial velocity of steam leaving the boiler. Where the pipe is small and the boiler is attached to a strong draft the high velocity of the steam is very likely to carry with it a spray of water, which will give no end of trouble.

Carrying the return back below the water line is condemned by some, but very much depends upon the layout of the apparatus. Of course, it goes without saying that where the pipes are submerged the water will cool and enter the boiler at a lower temperature than if these returns were carried back to the boiler overhead. In the latter case the water of condensation reaches the boiler with only a few degrees loss of heat. In the former case the loss may be of 50 degrees or more, and as a matter of course more coal must be consumed to evaporate the water from the lower temperature than from the higher.

There is, however, a compensating feature in submerged returns, in that they help to steady the water line in a boiler which has sensitive heating surface.

Sketch "B" shows the first floor plan of the building and the position of the radiators. Sketch "C" shows the second floor plan and position of radiators.

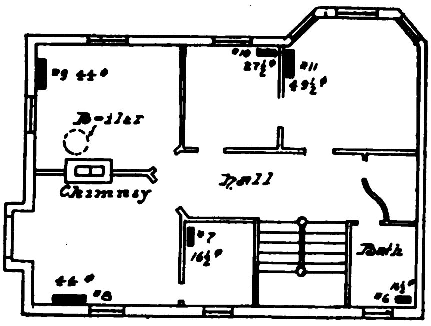

FIG. 111, SKETCH C—SECOND FLOOR PLAN

We regret very much that we have not the data covering the cooling surface of this house, as it would have been interesting and instructive to have figured the loss of heat of each room by transmission and compared with the radiation now installed.

We will say in conclusion that we are very much pleased with the general appearance of this work, as it shows good workmanship, the only two points of criticism, being the size of the riser from the boiler and the compound drop pipe at the junction of the two mains. Valving the risers is a matter of taste.

CHAPTER XXV.

PIPE SIZES—ONE PIPE SYSTEM.

SINCE writing Chapter 24 of this series of articles we have received a communication in reference to our comments on a low-pressure steam heating system under the captain "A one-pipe steam system with submerged return," shown on page 184 of THE PLUMBERS' TRADE JOURNAL, STEAM AND HOT WATER FITTERS' REVIEW, under date of February 15.

Editor THE PLUMBERS' TRADE JOURNAL:

In your February 15th issue appears a sketch of a one-pipe steam job submitted by Slemmer & Son, Centreville, Md. Your criticism of this job is quite complimentary to the designers, and you say: "We are very much pleased with the general appearance of this work as it shows good workmanship, the only two points of criticism being the size of the riser from the boiler and the compound drip pipe at the junction of the two mains." You object to the size of the riser from the boiler, or rather to the size of the distributing mains fed from it; suggesting that 1½ inches might have been used without lowering the efficiency of the apparatus in any particular.

Now, Mr. Editor, I have very little knowledge of and very little experience in the designing and constructing of steam heating apparatus and for that reason I make bold to take issue with your conclusions on this particular job; not with a desire to correct you, but with a desire to be corrected in so far as I am wrong. To determine the size of steam mains I have used the following rule: Divide the amount of direct heating surface in square feet by 100; divide the quotient by 0.7854; then extract the square root of the quotient: the result will be the diameter of the pipe in inches. There are 447 square feet of radiation shown on this particular job and according to the foregoing rule, $\frac{447}{100 \times .7854} =$ 2.48 inches. This would mean a 2½-inch main where it leaves the boiler. Now, Mr. Editor, as the apparatus is to supply 447 square feet of radiation plus nine radiators to be installed later on, it seems to me that the mains are too small to give satisfactory results. Assuming that the nine additional radiators would represent 250 feet of radiation, we have a total radiation of 447 + 250 = 697 square feet. This according to my rule would call for a 3-inch main leaving the boiler which should be reduced by a 3 x 2½ x 2-inch fitting at the point where the three-way ell now is. The main from which the nine extra radiators are to be supplied should be 2½ inches and the riser to same should be 2 inches.

As I do not consider myself an authority on such matters as I have herein discussed I will gladly welcome such criticism as these observations merit.

At the same time, Mr. Editor, I am looking for information on another matter: that is the functions of a check valve on a low-pressure gravity-return steam-heating job. Some fitters put them in, others do not. My question is: "Why is a check valve?"

In answer to this we must first express our regret that in Slemmer & Son's letter, as we printed it, there is a typographical error, and the words "nine radiators for rooms in third story" should read "a radiator for room in third story."

Regarding size of main leaving the boiler, we meant just what we said; that it is bad practice to have a less area in the riser from the steam dome than is in the distributing pipes, and this reason is explained in Chapter 33 of this series of papers.

As it is our intention to write at considerable length on the subject of pipe sizes, this is as good an opportunity as any to give the reasons for our belief in smaller steam mains than are used in ordinary practice.

The writer of the letter quoted above says that it is his practice to divide the amount of direct-heating surface by 100, divide the quotient by .7854, and from the result extract the square root, and call it the diameter of the required pipe in inches. We presume the writer thinks it better to have some kind of a rule for pipe sizes than none at all, although such a rule may have no scientific basis for its existence. If our correspondent can give any reason why he uses such a rule, or why he believes that smaller pipe sizes than his rule calls for are not desirable, we will be glad to hear from him.

It is the writer's firm conviction that the only scientific basis for determining pipe sizes is to compute the required sizes from the velocity of the steam in the pipes. For 1¼-inch and 1½-inch mains a fair velocity is 40 feet per second; for 2-inch to 3½-inch pipe, 60 feet; for 4-inch to 6-inch, 80 feet, and for 7-inch to 10-inch, a velocity of 100 feet per second is not too high.

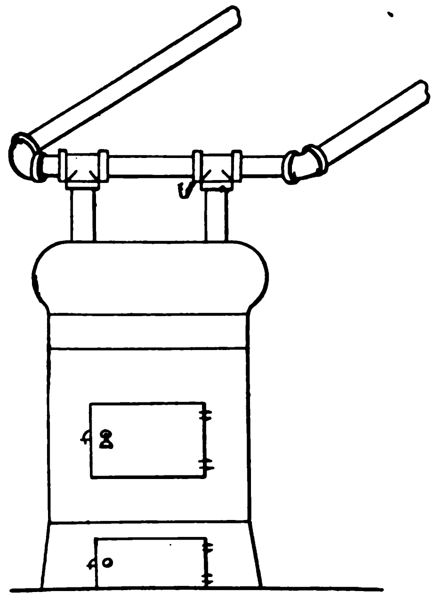

FIG.112—TWO 2-IN. MAINS. FROM STEAMHEAD

Let us then take the above named velocities as a basis and in the job under consideration where there are 447 feet, we find that one 2-inch main will carry the radiation with a velocity of 30 feet per second. If we use two 1½-inch mains the velocity in each main will be 25 feet per second. Now when the one 2-inch main is connected into the steam boiler, the initial velocity of the steam leaving the steam dome is 30 feet per second, which is too high for many of the types of modern house heating boilers, and for this reason two 2-inch pipes should rise from the steam head, and be connected into one 2-inch steam pipe, or it would be better practice in the job under consideration to have each 2-inch main taken directly out of the steamhead, connecting the two together in a yoke as shown in Fig. 112. In this way the initial velocity would be reduced to 15 feet per second, which is high enough for boilers that contain sensitive heating surface.

In the next case cited by our correspondent, where there are 697 feet of radiation, he suggests a 3-inch main. This could be done on a 2-inch main with a velocity of 48 feet per second, but from the steam head *two* 2½-inch risers should connect to the 2-inch main, making the initial velocity from the steam dome 17 feet per second.

The writer has in successful operation a job of steam heating, where there are eleven radiators containing 450 feet of radiation. The circuit of pipe is 1½-inch and is 165 feet in length, and it would be impossible to have a job work any better than does this one. A sketch of the apparatus is shown in Fig. 113.

Another installation designed by the writer carries 750 square feet of radiation on one 2-inch main. This, however, is a short run, and the radiators have a return pipe as is shown in sketch 114, but if there were but one pipe and twenty radiators, and the run were 150 feet in length, the one 2-inch pipe would do all the work satisfactorily.

Let us now take 5,000 square feet of radiation, which, if figured by our correspondent's rule, will require an 8-inch steam main, but by our deductions a 5-inch main will be ample, giving a velocity in the steam main of 58 feet per second. Rising from the steam head of the boiler should be three 5-inch pipes connected into this one 5-inch main, giving a velocity of 19 feet per second out of the steam dome.

Ten thousand square feet of radiation figured by our correspondent's method will require two 8-inch mains. We would use one 7-inch main with a velocity of 60 feet per second. From the steam head of the battery of boilers we would take three 8-inch pipes connected to the 7-inch main, giving us an initial velocity out of the steam domes of 15 feet per second.

For 30,000 feet of radiation our correspondent would require an area of 295 square inches, or three 10-inch and one 9-inch steam main. For 30,000 feet of radiation, situated within 1,000 feet of the boilers, we would use one 10-inch main, giving a velocity of 87 feet per second. From the battery of boilers, which would be necessary, we would take out enough openings to keep the initial velocity down to 15 feet per second.

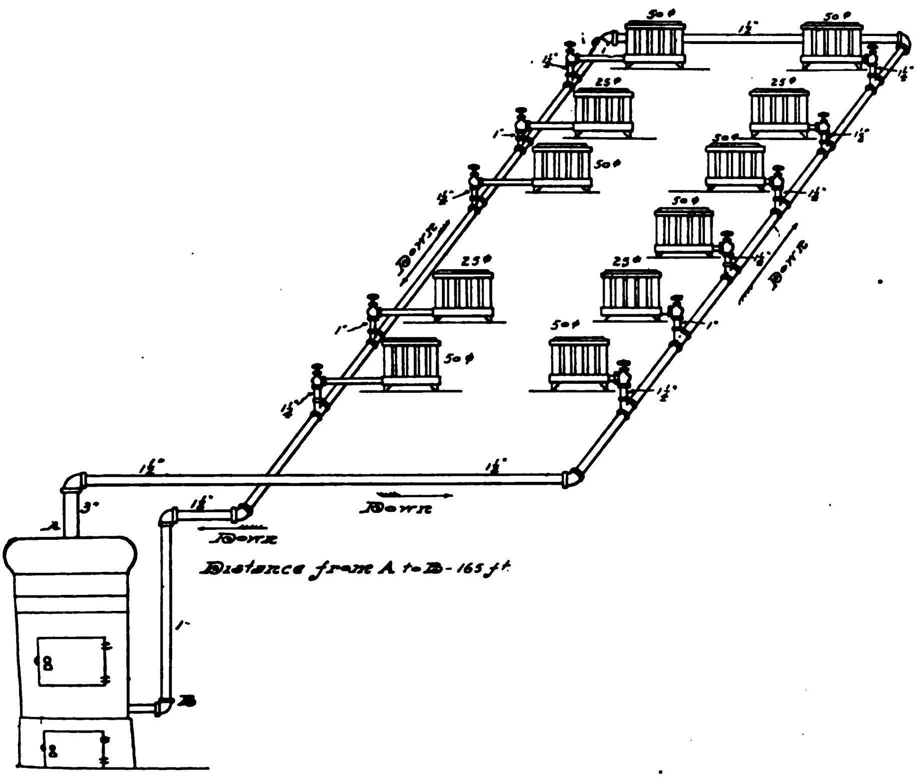

FIG. 113—A SUCCESSFUL STEAM HEATING JOB, ELEVEN RADIATORS CONTAINING 450 FT. RADIATION CARRIED ON A 1 1-2 INCH CIRCUIT

A job of this kind is now in operation, where the radiation is almost exactly 30,000 square feet. The main steam pipe is 10 inches in diameter. The main return pipe is 4 inches in diameter. There is a battery of four boilers, and out of the steam head of each boiler are four 6-inch risers. These four 6-inch risers connect into one 6-inch main, which in turn is connected into the 10-inch main steam line, and by this method the initial velocity of the steam leaving the boilers is 15 feet per second. When it reaches the 10-inch main the velocity rises to 87 feet per second.

In talking this matter over a few days ago with a prominent steam heating contractor, he said that he was now convinced that he had thrown away half a fortune in using unnecessarily large pipes in his practice. He had given the subject much thought in the last few years, but it was not until the present heating season that he mustered up sufficient courage to install a fifteen-radiator job containing 650 feet of radiation on one 2-inch steam line. He said he was prepared to take the pipe down and put in larger, but to his surprise the apparatus is working better than any other job he knows of.

The theory that a steam job cannot be spoiled by having the pipe too large is wrong. In the first place, a large pipe imposes an unnecessary tax on the boiler. In the second place, the steam velocity is so reduced that it takes the heat longer to reach its destination than where the pipe is smaller. In saying this, the writer is not overlooking the fact that in long runs the frictional resistance must be taken into consideration, but where velocities are given in the foregoing examples the frictional resistance is taken care of for all ordinary house-heating work.

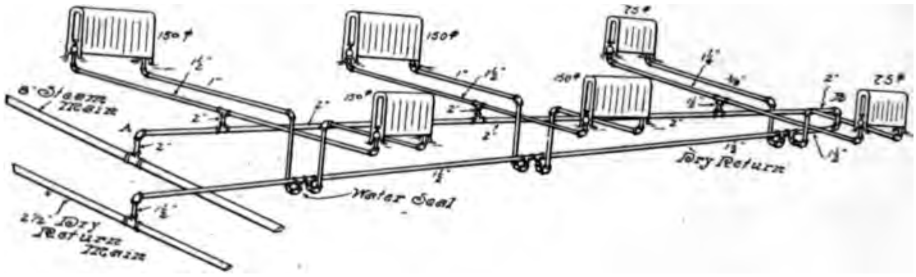

FIG. 114—SIX RADIATORS CONTAINING 750 SQ. FT. ON ONE 2-INCH PIPE. DISTANCE FROM A TO B 80 FT.

Our correspondent asks our opinion of the functions of check valves on low-pressure steam-heating apparatus. It is our belief and experience that the check valve is the "vermiform appendix" of low-pressure steam plants, inasmuch as it is a useless appendage and very frequently must be removed to give the patient (apparatus) relief.

The reason for applying check valves to the return lines of steam-heating apparatus is because the steam fitter, finding water in the radiators, believes the water is being pushed out of the boiler through the return, and to prevent this the check valve is inserted in the return pipe near the boiler, with the check against the boiler pressure. This is done to prevent the water backing out of the boiler where there is supposed to be an unequal pressure. If the pressure is unequal and a check valve is applied it is obvious that the water must rise in the return pipe until sufficient head accumulates to balance the pressure before the valve will open and allow the water to return to the boiler, thus producing an intermittent return of the water of condensation, which is not a desirable feature.

Sometimes the water will disappear out of the glass of a steam boiler when the pressure rises, and this is usually attributed to water leaving the boiler through the returns, when as a matter of fact it is caused by the draft or suction on the bottom of the pipe which connects the water column to the boiler. When water enters the radiators it is usually through the steam pipes, and is caused by the high initial velocity carrying a fine spray of water with the outgoing steam. This can always be prevented or remedied by taking a number of large openings out of the steam head, as described in this and former articles.

CHAPTER XXVI.

AN UNSATISFACTORY STEAM HEATING APPARATUS AND HOW IT WAS REMEDIED—SOME CRUDE METHODS IN WATER HEATING.

IN this chapter we show a number of sketches, which represent steam and water heating apparatus installed during the present heating season in different localities.

Fig. 115. represents a steam heating plant installed in a small residence, which has been giving a great deal of trouble. The boiler has a rated capacity of 500 square feet, and the piping and radiation attached figure up 420 square feet. Out of the top of the boiler there are two 3-inch tappings for steam pipes. One of these the fitter plugged, the other he bushed to 2½ inches, and to this was connected a 2½-inch riser, which rose from the steam dome about 2 feet, and was then carried 4 feet to the front of the boiler. At this point was placed a 2 x 2 x 2½-inch tee, and one 2-inch steam line was run to the front of the building, and another 2-inch line to the rear. The radiator connections are not all shown on the piping, as it is only necessary to show the branch lines which were improperly run. The 2-inch line which is carried to the front of the building drops into a return, which is taken back to the boiler below the water line, and from the top of the tee on the end of this 2-inch pipe is carried a riser to the second floor.

The hall radiator is situated 16 feet from the 2-inch main, and the branch of that radiator was 1¼-inch pipe run on a dead level. If this arm had been 1½-inch and pitched up toward the radiator, it would probably have worked all right, but as it was installed, the steam carried the water into the radiator, causing a great deal of trouble and annoyance.

The rear line, however, was still worse. On this line there are 240 feet of radiation, and at the end of the 2-inch pipe a bleeder is carried down beneath the floor and back to the boiler. This bleeder was 1½-inch. From the top of this bleeder a 1½-inch pipe rose 6 inches and was then carried to the rear end of the basement, where it was connected to a 1¼-inch riser leading to the second floor. This line was the cause of a great deal of water hammer, and as a remedy, the steam fitter run a ¾-inch bleeder from the bottom of the 1¼-inch riser and connected it to the 1½-inch bleeder. In doing this he overlooked entirely a most decided trap which was in the pipe where it was connected with a union coupling, as shown at "A." This trap was about one and a half times the diameter of the pipe, and still the fitter said he had never seen it until his attention was called to it. How it was possible for him to overlook this, it is hard to say, as it was in plain sight.

In firing this boiler the water would leave the gauge glass as soon as pressure began to show on the gauge, and at one pound pressure the water would be all out of the glass, and beside this the water could be distinctly heard surging through the pipes and radiators. The boiler is constructed with very sensitive heating surface, that is to say, 80 per cent. of the heating surface comes in direct contact with the radiant heat of the fire, and all such boilers will make steam very rapidly when attached to a strong draft.

By using only one 2½-inch opening, the velocity of steam leaving the steam dome was 20 feet per second, which is entirely too high for boilers of this type.

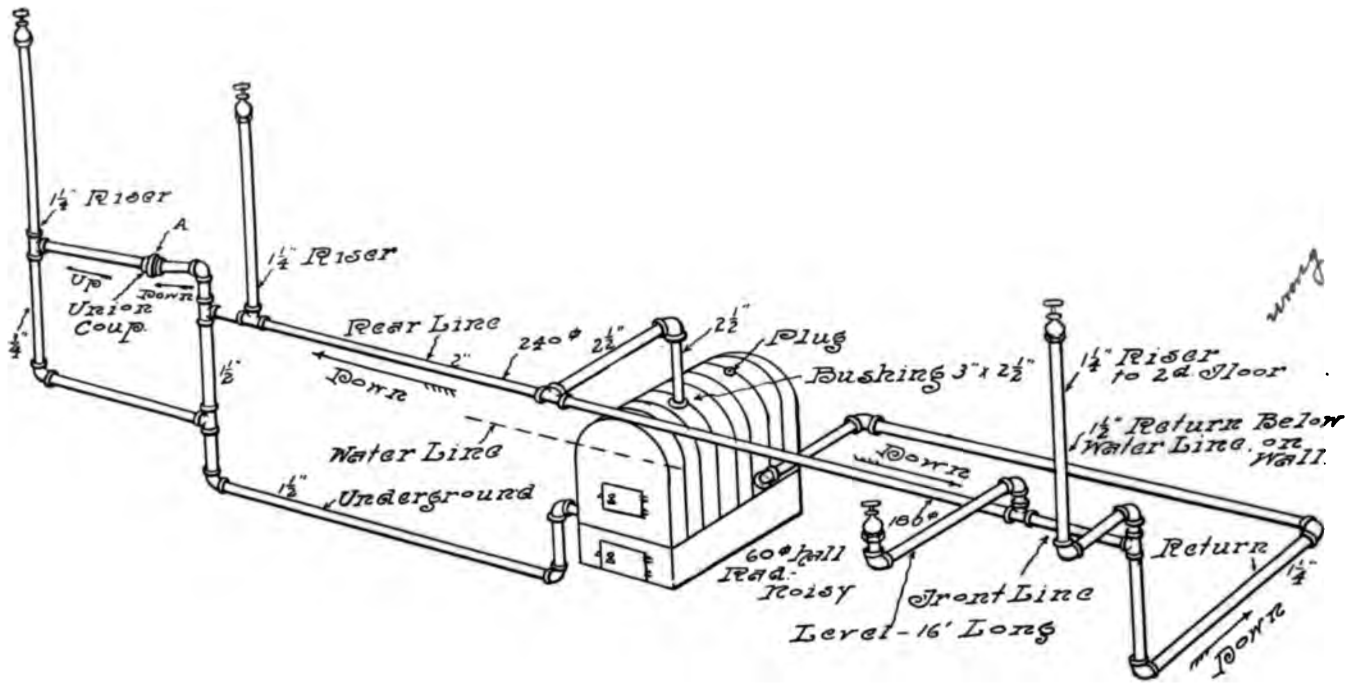

FIG. 115–STEAM HEATING. BOILER PRIMES WATER HAMMER AND NO HEAT

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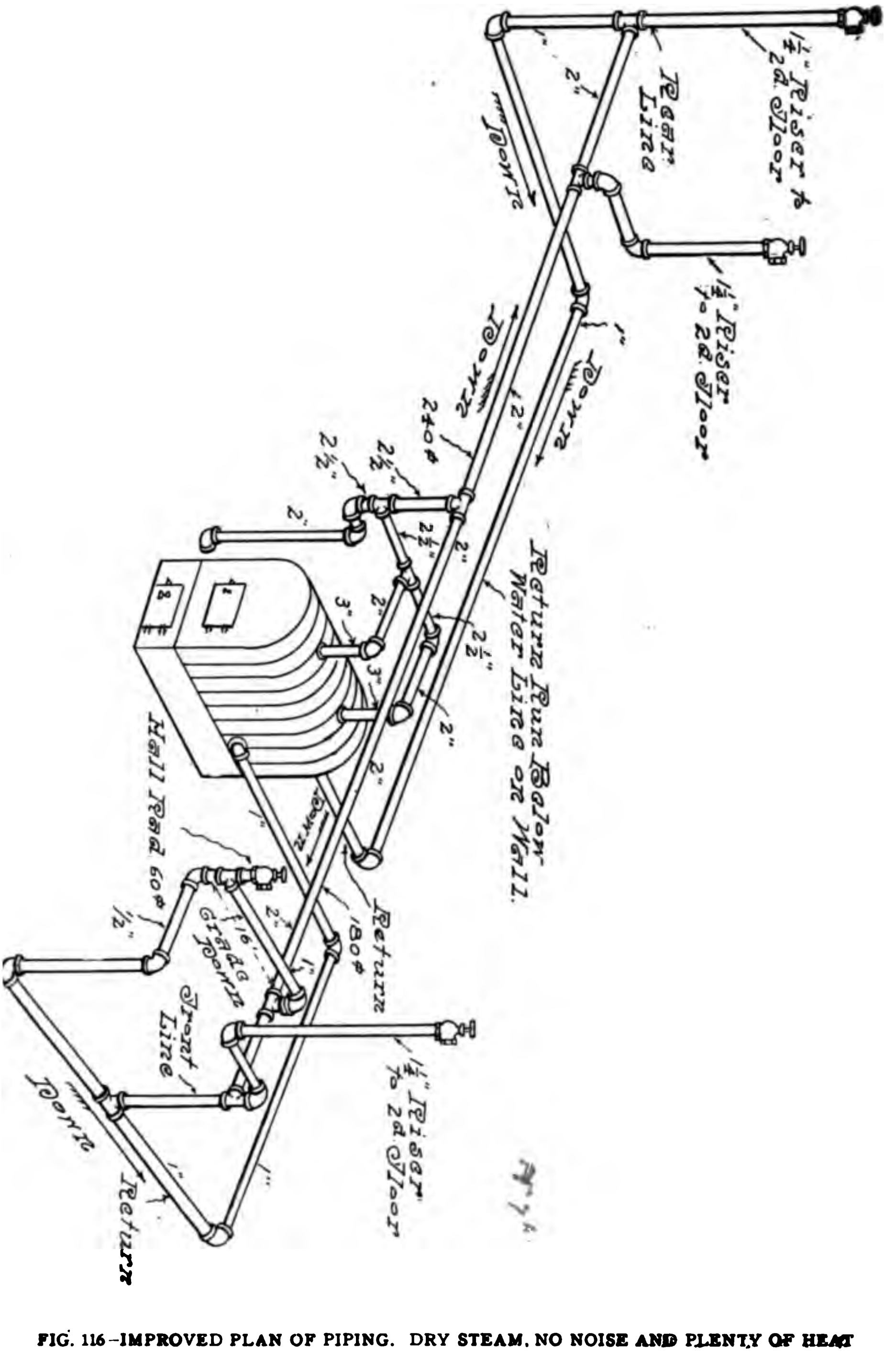


FIG. 116—IMPROVED PLAN OF PIPING. DRY STEAM, NO NOISE AND PLENTY OF HEAT

We have repeatedly called attention to the bad practice of bushing steam openings in modern house heating steam boilers. Wherever the practice is indulged in more or less trouble will ensue.

Turning to Fig. 116, a sketch is shown of the manner in which the work has been reconstructed. It would have sufficed to take another 2½-inch opening out of the steam head, but as an object lesson to the steam fitter, the full size of the openings are used, as is shown in the sketch. Two 3-inch risers are connected to the steam head, terminating in ells 3 x 2 inches; these 2-inch pipes connect into a yoke or cross arm of 2½-inch pipe, which is carried to the front of the boiler. Here is placed a 2½-inch tee, from the top of which a 2½-inch pipe is run to the ceiling, terminating in a tee 2 x 2 x 2½ inches. From the bottom of the 2½-inch riser an equalizing pipe is carried back to the return of the boiler. This equalizing pipe is 2½-inch for about 12 inches, where it reduces to 2 inches, and is carried to the boiler that size.

To the hall radiator a 1-inch branch is run, which pitches down from the main to the foot of the radiator stub, and from the bottom of this stub or riser a ½-inch drip pipe is run into the main return, which is carried along the wall below the water line and back to the boiler. The 2-inch rear steam line is carried to the extreme end of the basement, at which point a 1¼-inch riser is run to the upper floor; from the foot of the 1¼-inch riser the return, 1-inch in size, is carried back to the boiler along the wall, instead of beneath the basement floor. Since these changes were completed the apparatus works perfectly.

The hall radiator heats up rapidly and without any noise. The water in the gauge glass remains perfectly steady at any pressure from 1 to 10 pounds. The sizes of the steam lines were not changed, though they would be equally efficient if they were 1½-inch instead of 2-inch.

Fig. 117 is another specimen of bad practice, which was recently installed in a small residence. In this job there are about 400 square feet of radiation, and the pipes were run as shown in the sketch; one 2-inch line to the front of the building and another 2-inch line to the rear. The apparatus worked very unsatisfactorily. The water would leave the gauge glass the moment pressure began to rise, and beside this the radiators throughout the building would fill with water, and make a great deal of noise. The radiators were connected to the rising lines as shown in the sketch; the main was held rigidly by a chain hanger so that the expansion of the pipe was upward and lifted the front end of the radiator, causing it to fill with water. The radiators, however, would fill with water from the boiler priming through the small outlets.

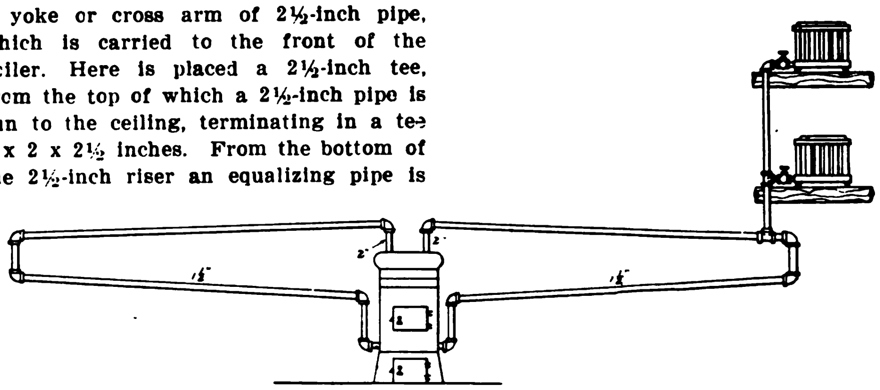


FIG. 117—THE WRONG WAY. THE BOILER PRIMES; RADIATORS FILL WITH WATER. NOISY AND INEFFICIENT

This job was reconstructed, as shown in Fig. 118, and is now giving perfect satisfaction. The main pipe lines were not disturbed, although had we been planning the job originally, we would use 1½-inch steam lines and 1-inch returns. In making the change, as may be seen by the sketch, two 3-inch risers are taken out of the steam dome, which are connected into a 2-inch cross head, and two

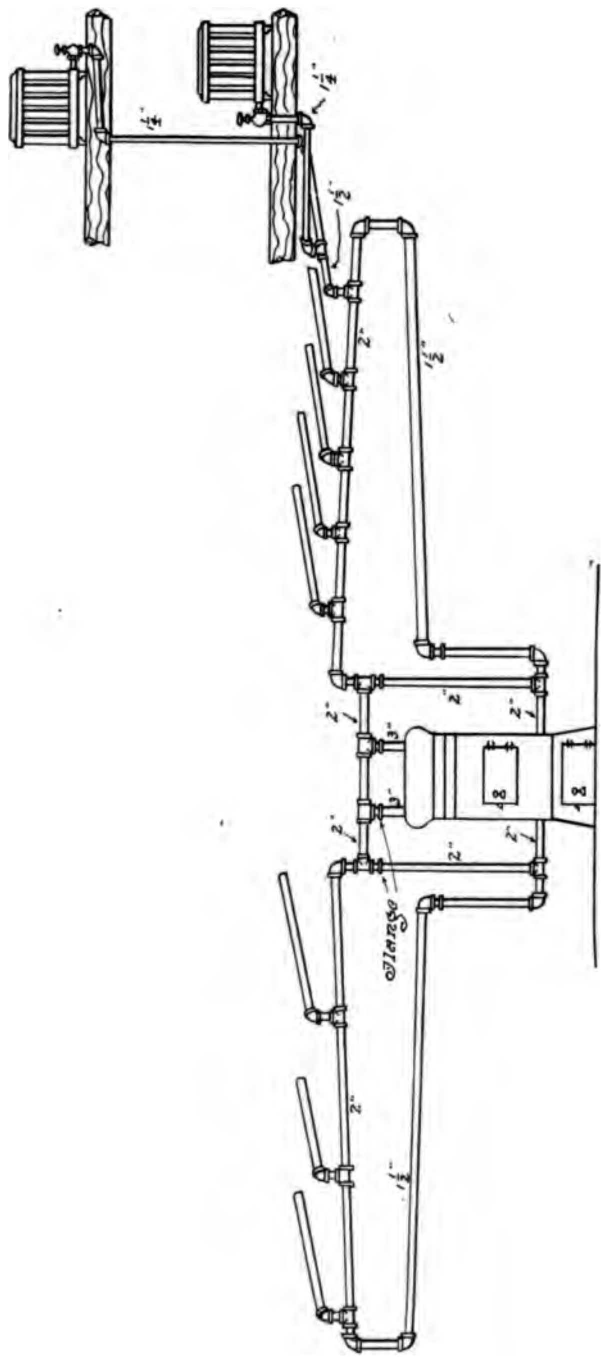


FIG. 118—STEAM HEATING. THE RIGHT WAY. DRY STEAM. NOISELESS AND EFFICIENT

2-inch bleeders, or equalizing pipes, are dropped back to the returns of the boiler. This arrangement would not have been necessary if the job had been planned properly at first, but as the apparatus was a particularly aggravating one, it was considered best to be sure and get it right. If the boiler connections had been run originally as is shown in sketch 119, much trouble and expense would have been avoided.

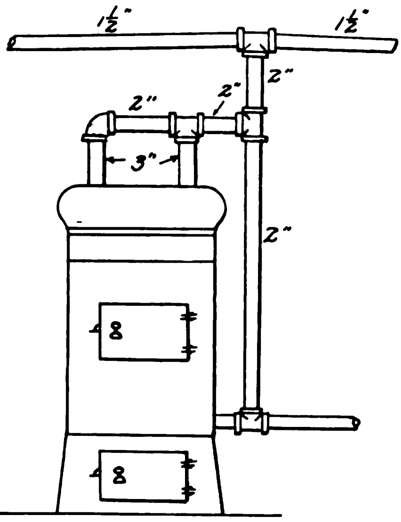


FIG. 119—BOILER AND PIPE CONNECTIONS

Fig. 120 is a hot water heating apparatus which was recently inspected by the writer, and which was not doing satisfactory work. In this case the boiler was set in the middle of the basement, as is the custom of the steam heating fraternity in that locality. This necessitated a smoke pipe 16 feet in length, and made some awkward and unnecessarily long runs to a portion of the radiation. An improvement of this sketch is shown in Fig. 121, where the boiler is set close to the chimney, and the run of pipe to the kitchen radiator is shortened 13 feet, using but one main instead of two. The connection of the dining room radiator is also shortened from 18 feet to 3 feet. Since making these changes the apparatus is giving entire satisfaction to all concerned. When the boiler occupied the middle of the basement with 16 feet of pipe to it, the draft was insufficient, and neither the dining room or kitchen radiator could be made to heat equally with other radiators in the house. Shortening the smoke pipe improved the draft, and shortening the water piping improved the circulation in the radiators mentioned.

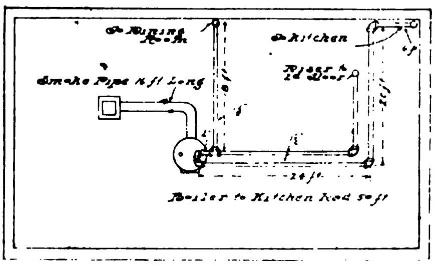


FIG.120—HOT WATER HEATING. POOR LAYOUT

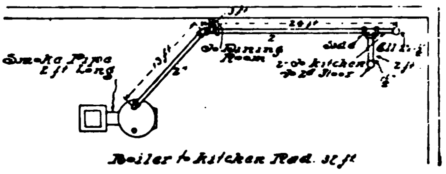


FIG. 121—HOT WATER HEATING. IMPROVED PLAN

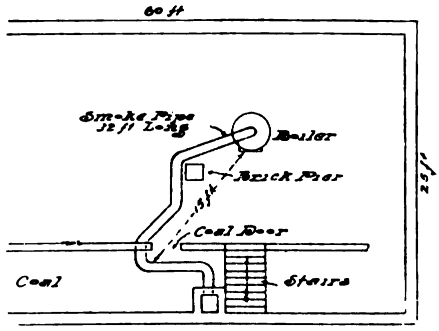


FIG. 122—HOT WATER BOILER IMPROPERLY LOCATED

In Fig. 122 is shown another case of trying to keep the boiler near the center of the basement. In this case, however, we think the boiler must have been set by chance, or in the dark, as it is almost inconceivable that a man of any experience would run a smoke pipe in the manner described. After the boiler was set in place and piped up, it was found that

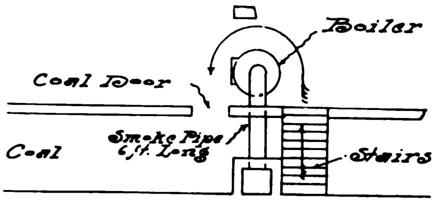


FIG. 123—HOT WATER BOILER PROPERLY LOCATED

if the smoke pipe were taken direct to the chimney, it would be in the way of the boiler attendant. The pipe was then carried around a brick pier and started again for the chimney, but here the coal door interfered and another kink was put in it to clear this opening. After the pipe entered the coal bin, two more elbows carried it to the chimney. Here are six elbows in one piece of smoke pipe, and a length of 32 feet. The chimney in this case had an excellent draft and the boiler was doing fairly good service. It is the intention, however, when the heating season is over, to change the location of the boiler to the position shown in Fig. 123, where it should have been set in the first place. Here the smoke pipe will be 6 feet in length and have one elbow, and there will be plenty of room between the brick pier and the boiler for the attendant to pass, and beside this he will then be able to stand in one position and take fuel from the coal bin and deliver it to the boiler. In the present location coal must be carried in shovelfuls a distance of 15 feet.

CHAPTER XXVII.

A DANGEROUS INSTALLATION IN WATER HEATING.

FIG. 124 is the floor plan of the fourth story of a factory building in which a steam heating plant was recently installed. Fig. 125 is a section showing the third and fourth floors. It is not necessary to show any other part of the apparatus, as our remarks have to do with these two floors only.

There are 550 square feet of radiation on the third floor, and 1,050 feet on the fourth floor. There was no difficulty in maintaining a temperature of 70 degrees on the third floor during the past winter, but it was impossible to raise the temperature of the fourth floor above 50 degrees on the coldest days.

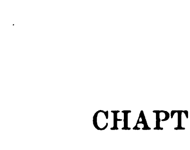


FIG. 124—FLOOR PLAN OF THE FOURTH STORY OF A FACTORY BUILDING

The contractor who placed the radiation guessed at it from the first, and placed 850 feet of radiation on the fourth floor. When it was found impossible to warm the room, 200 square feet of radiation was added until, as stated, there are now 1,050 feet on this floor, and still the room is not sufficiently warm.

It is the writer's experience that in many buildings the steam fitter wholly ignores the cooling influence of the roof, and in factories like the one we are describing, where there is nothing to prevent the loss of heat through the roof, except a layer of boards covered with tar and gravel, the loss is frequently greater than it is through the walls.

On the fourth floor there are 92,232 cubic feet of air space. There are 1,160 square feet of glass, 1,192 square feet of exposed wall, and 6,588 square feet of exposed roof. As the air in this room will change once per hour because of the rapid loss of heat and the excessive amount of glass, there will be required to warm the air 540 square feet. The glass will require 350 square feet; the wall 110, and the roof 550 square feet, making a total of 1,550 square feet, which leaves 500 square feet to be added to the present radiation, to maintain a temperature of 70 degrees when the external temperature is at zero. This is nearly three times as much radiation as is required on the third floor. This great difference in the cooling effect of the two rooms is due—first, to a less frequent change of air on the second floor; second, to a lathed and plastered ceiling, which forms air spaces between ceiling and upper floor; and third, to a much smaller glass exposure.

The air space of the third floor is 60,000 cubic feet, which requires 200 feet of radiation. There are 520 feet of glass, which requires 155 feet of radiation, and 1,500 square feet of exposed wall, requiring 140 square feet. The total radiation required would be 495 square feet, as against 550 square feet in service.

The ratio of radiation to cubic feet of air is: fourth floor, 1 to 88; third floor, 1 to 110. When the additional radiation is placed on the fourth floor the ratio will be 1 to 60. It is evident that if any figuring was done to arrive at the radiation required, it was by dividing the cubic feet of air in each room by 110.

Another feature of this installation is the loss of money sustained by both owner and contractor. The work was let to the lowest bidder, who happened to be a man who knew absolutely nothing about the heating business. His experience is confined to furnishing and attaching an odd radiator here and there, or doing some piping repairs. His bid was so much below that of the regular steam heating concern that the owner felt he could not overlook it. When it was found to be impossible to heat the fourth floor, the contractor was called upon to furnish additional radiation and has at his own expense put in the 200 additional square feet. Now that 500 feet additional radiation is required, he finds himself unable financially to get any further, and consequently the owner is now obliged to turn the work over to a reputable steam heating concern, who find they will have to remodel the piping before the building can be properly heated, and when the

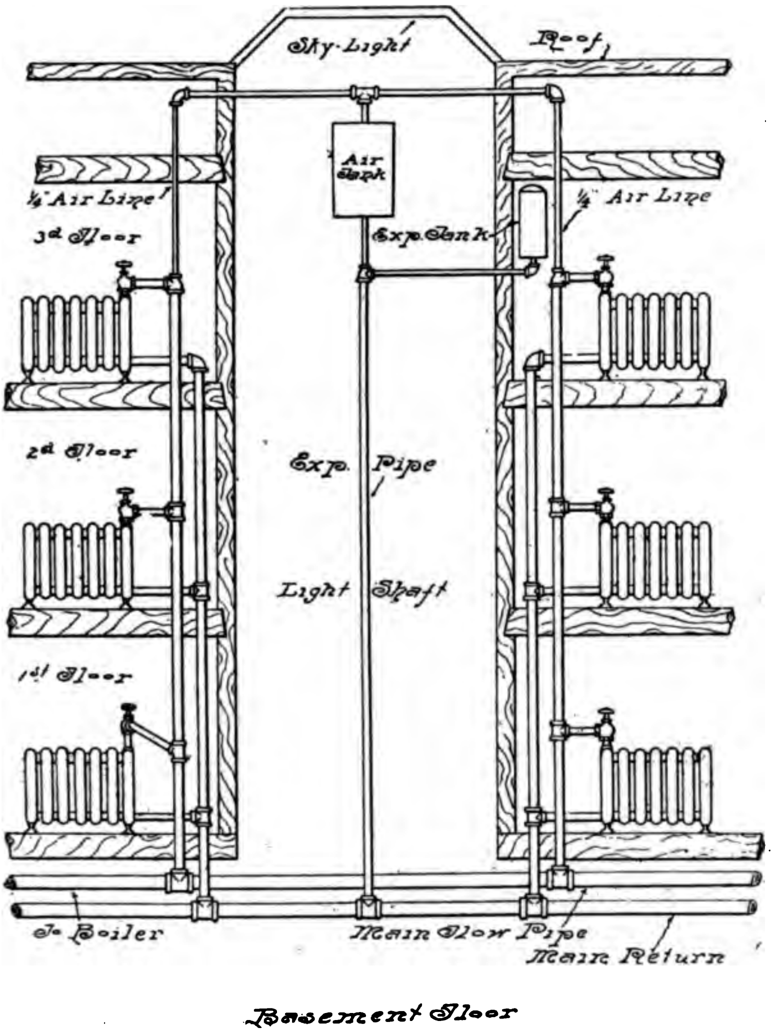


FIG. 126—SECTIONAL VIEW OF A 3-STORY BUILDING, IN WHICH WAS INSTALLED A HOT WATER APPARATUS

work is completed, the owner will have paid out between $200 and $300 more than he would have paid originally for first-class work.

In some of the trades and professions there are laws intended to prevent the operation of botches, but the heating business seems to be fair game for anyone who feels inclined to take a shy at it.

Fig. 126 is a sectional view of a three-story building in which was recently installed a hot water heating apparatus. The illustration shows only that part of the apparatus which is the subject of our criticism.

It is not our purpose to criticise the size of the mains and piping, which is much smaller than is the usual practice, as we are well aware that where a piping plan is properly proportioned in all its parts, much smaller piping may be used than where the piping is improperly proportioned.

In this installation the flow pipe rises to the top of the radiator on the third floor. These radiators are specially tapped into the top of the loop, on which is placed an angle valve which is connected to the flow pipe. This special tapping is both unusual and unnecessary. A tapping into the side of the loop at the top would answer the same purpose and look neater.

The return pipe is taken out of the radiator at the bottom on the same side, to which there is no objection. An air line is carried from the top of the rising line and connects into the top of an air tank, as is shown on the sketch. This air tank is placed in the top of an air shaft, which is surmounted by a skylight. From the bottom of the air tank a pipe is run through the partition into a bath room, where there is a small expansion tank. There are no overflow pipes or vent pipes, nor is there on any part of the apparatus a safety valve. Why the two tanks are used is a mystery. When the apparatus is filled with water the air is driven from the pipes and radiators into the air tank, where it is compressed by the head of water. It is to be supposed that when the apparatus was first filled, the pet cock in the bottom of the expansion tank gauge glass was opened, which would allow the air in the system to escape at that point, otherwise unless there was a high water pressure the air tank would not be sufficiently large to contain all the air in the apparatus. The plant has now been in operation for some weeks, and while the building can be warmed, there is constant trouble from leaks on cold days when it is necessary to increase the temperature of the water, which expands the water and increases the pressure, and as there is no place for additional expansion, except to compress the air in the small tank, something must give way.

All the fittings in the job are malleable iron, it being evident that the designer of the apparatus was afraid of using cast iron fittings lest the excessive pressure would break them. If the job had been made perfectly tight it is likely some of the radiation would have broken before this and flooded the building, but the leaks in the apparatus have served the purpose of a safety valve. The job throughout looks as though it was done by farm hands. One radiator on the first floor is connected into the riser in such a manner that the pipe is trapped a little more than its full diameter, yet this radiator heats apparently as well as any of the others. This is due to the fact that the head of water compresses the air into a small volume in the top of the pipe and allows the water to enter the radiator along the bottom of the pipe. Another radiator has the return end trapped so that it will be impossible to empty the radiator of water. Of course, these connections were not made by design. They just happened to come that

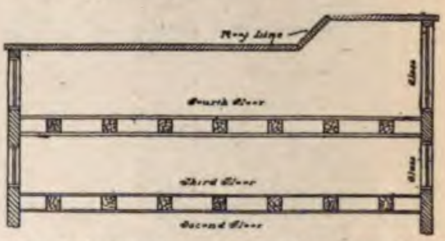


FIG. 125—SHOWS THIRD AND FOURTH FLOORS

way and were left so either through ignorance or carelessness.

The contractor for this apparatus is not and never was in the heating business, but having nothing else to do he thought he might turn an honest penny by taking a contract for heating this building. He got the contract because his price was far below that of any of the established heating trade. While the apparatus is in its present form, it is a constant menace to the owner and occupants of the building, although they do not seem to realize it. The radiation in the building is sufficient to heat it, and that seem to be about all they care for, but some fine cold day one of the radiators will let go and the building will be be flooded and the consequent damages will probably be sufficient to pay for a first-class apparatus installed by competent and responsible heating engineers.

CHAPTER XXVIII.

WATER HEATING APPARATUS—ANCIENT AND MODERN METHODS OF PIPING COMPARED.

WE are in receipt of a communication in regard to hot water heating, of which the following is an extract:

> I would like your views in regard to running the pipe for a hot water heating apparatus, to be installed in a house as represented in the accompanying plan, sketch No. 1. There are 400 feet of direct radiation. As you will see by the plan, I start with a 3-inch main, running it in the usual manner in the basement under the first floor, terminating at the kitchen radiator, which contains 25 square feet. Instead of running the return in the usual manner, I begin at the radiator in the wash room with 1-inch pipe, and gradually enlarge the return until the size where it enters the boiler is 3 inches. I wish to know if this arrangement will work all right and give as good service as though it were regular 2-inch pipe work. I would also like a suggestion as to the proper place to locate the expansion tank, and the best method of taking care of the vent and water of expansion. Any information on this subject will be appreciated.

Referring to sketch No. 1, Fig. 127, submitted by our correspondent, we note that the flow pipe pitches down from the boiler until it reaches the kitchen radiator, where it terminates. There does not appear to be any arrangement for taking care of the air in the piping, which would accumulate above the boiler. The return from the kitchen radiator enters the 3-inch return line and the radiator will drain at the return line when the apparatus is empty, but the flow pipe will remain full of water, because there is no way of draining it. This flow pipe should be carried on past the kitchen radiator to the boiler, and there be connected to the return. This would stimulate circulation in the flow pipe and provide a means for draining the entire apparatus.

The system of piping shown by our correspondent is not new. It was quite extensively practiced in England some years ago, but has been abandoned for better methods. The serious objection to such an installation is the excessive quantity of pipe required, and the increased cost over almost any other system.

In the piping plan shown by our correspondent, where there are 400 feet of radiation, there will probably be 200 feet or more of piping, which adds to the boiler load and increases the fuel consumption.

We would also call attention to the fact that although the 3-inch flow pipe passes within a few feet of the kitchen radiator shortly after it leaves the boiler, the water is carried clear around the house, probably 60 or 80 feet before entering that radiator.

We are unable to tell from our correspondent's sketch which radiators belong to the first and which to the second floor, and in our sketch we have assumed that there are three radiators on the second floor. Whether there are more or less will not affect in any way the piping layout as we show it.

It is well known by men who have had large experience in hot water heat apparatus, that in a small compact job, a 2-inch main will carry four or five hundred square feet of radiation if properly arranged, following proper rules.

In our sketch, Fig. 128, we show a 2½-inch main leaving the boiler. On the end of this 2½-inch pipe is placed a 2½ x 2 x 2-inch tee, and two 2-inch lines are carried around each side of the house, in opposite directions. The high point is at the boiler, and from the top of the riser from the boiler the expansion pipe is carried to the expansion tank on the second floor, and relieves the entire piping system of air. The line marked "A" enters the side of the main line and carries five radiators containing 180 square feet; the line marked "B" carries six radiators containing 185 square feet. The 1-inch line marked "C" carries one radiator containing 30 square feet, making a total of 12 radiators containing 395 square feet. On line "A" the first four radiators are taken off the top of the 2-inch main and returned into the side of same. The last radiator on this line takes its flow from the top of the 2-inch main, and returns into the 2-inch return line, which runs along the wall within about 2 feet of the floor line, as shown by dotted line. On the line marked "B" the first two radiators take their flow from the top of the 2-inch main and return into the side of same. The last four radiators on line "B" take their flow from the top of the 2-inch main, and the returns from these four radiators drop into the 2-inch return line, which is carried along the wall underneath the flow pipe. This return line follows the wall of the house until it reaches the boiler. If it can be carried into the boiler without dropping to the flooor, well and good. If inconvenient to do so, it may be carried under the floor line and then raised to the boiler without making any appreciable difference in the circulation of the system. It is always well, however, where the return must rise 18 inches or more to enter the boiler, to run a small pipe from the flow pipe as it rises from the boiler and connect it to the bottom of the return line which rises to the return tapping of the boiler. In this way the water in the return is lightened at the point where it enters the boiler, which helps to increase the rapidity of the circulation throughout the system. This starting pipe, as it is called, is shown in detail in Fig. 131.

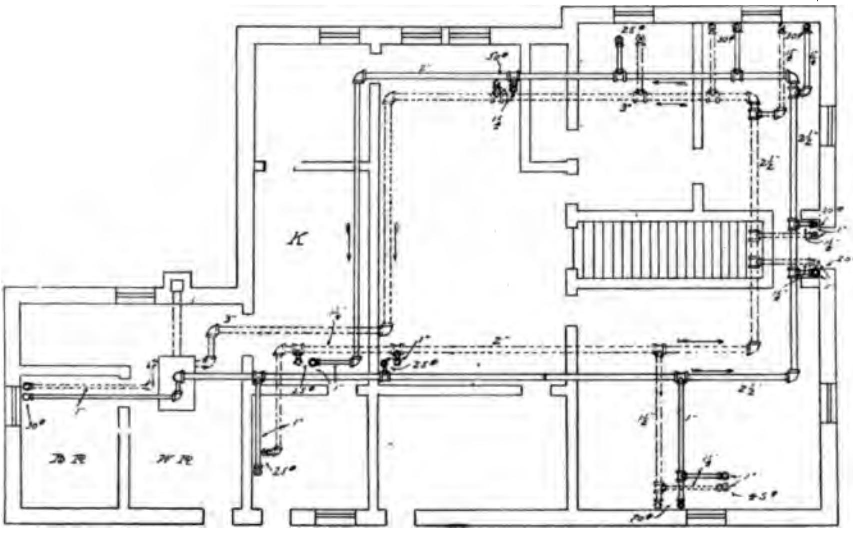


FIG. 127. SKETCH NO. 1—SHOWING THE PIPING PLAN FOR HOT WATER APPARATUS

In our sketch, Fig. 129, we show an isometric view of the piping on the floor plan, Fig. 128. We here show a 2½-inch pipe rising from the boiler. From the top of this pipe is carried a ¾ expansion pipe, which connects to the bottom of the expansion tank, which is placed on the second floor, or above all radiators. The 1-inch vent from the top of this tank may be carried out doors, or may be connected into a vent pipe. If it is carried through the wall out doors, an elbow and short nipple should be put on the end to prevent snow from entering.

Another method of connecting the ex-

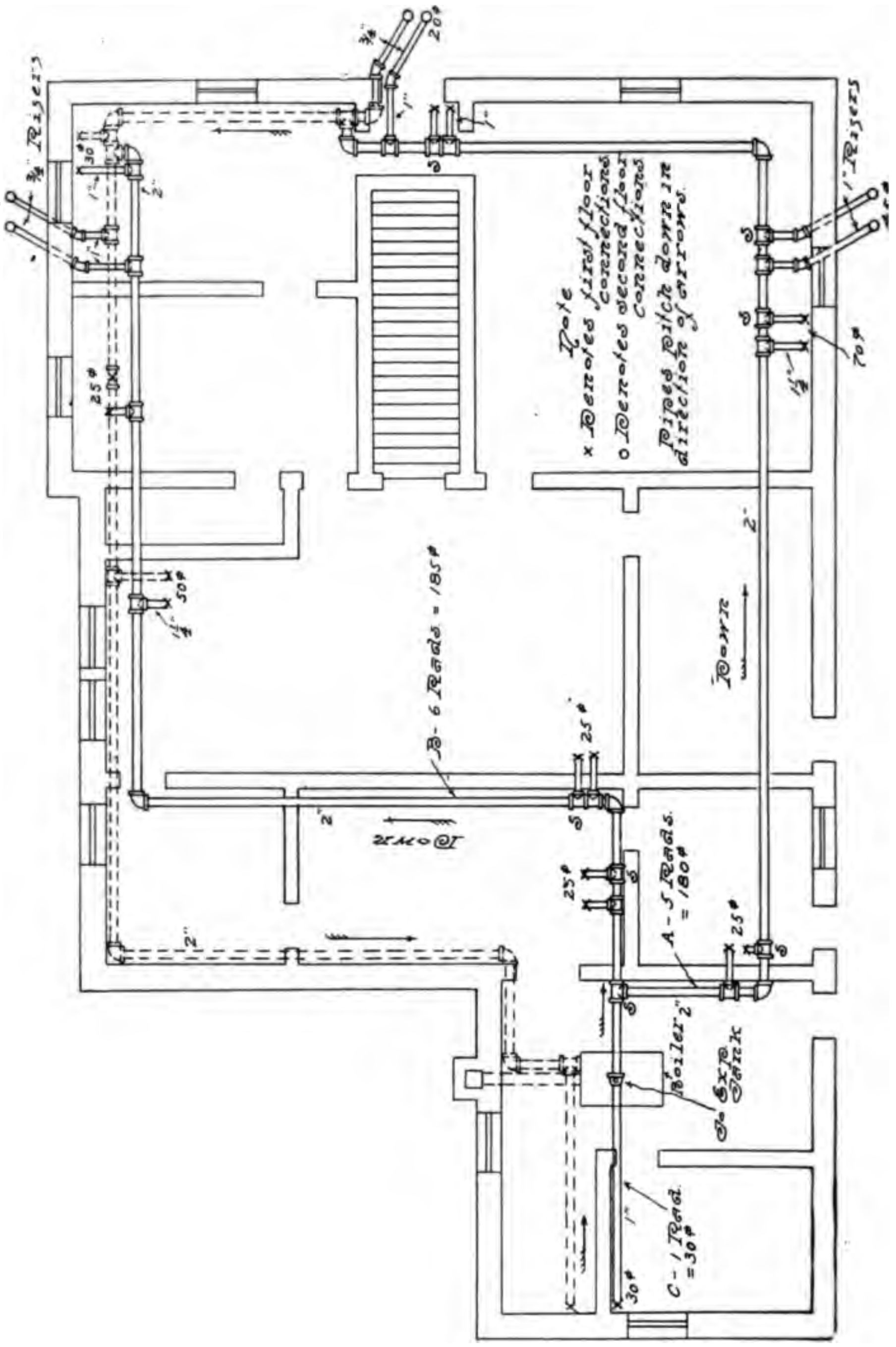


FIG. 128. SKETCH NO. 2—ONE PIPE PLAN FOR HOT WATER APPARATUS. TWO AND ONE-HAI INCH MAIN LEAVING BOILER

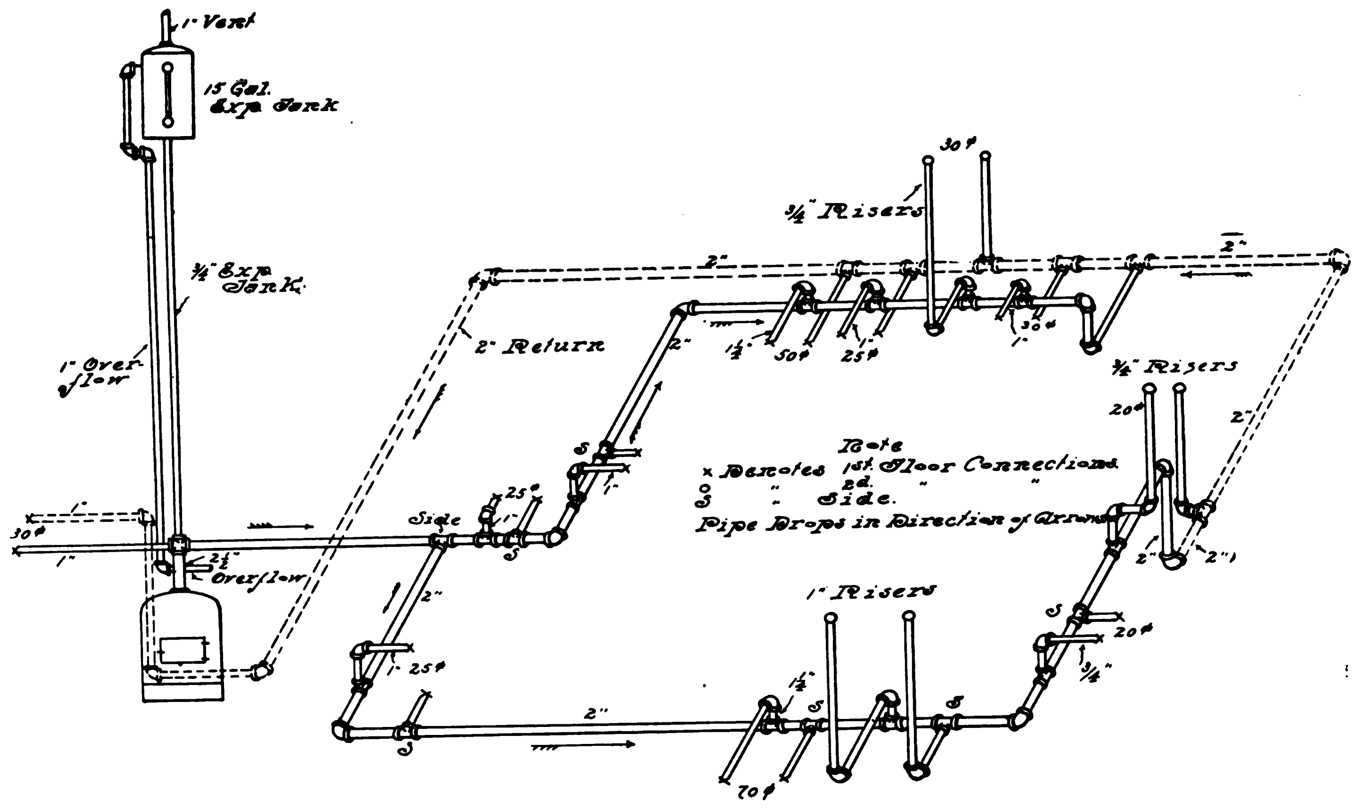


FIG. 129. SKETCH NO. 3—ISOMETRIC VIEW OF PIPING SHOWN IN OUR SKETCH NO. 2

pansion tank is shown in Fig. 130. This is sometimes done where there is no danger of the end of the pipe freezing. If the water should boil over in the apparatus, it will be thrown out through the 1-inch vent and overflow. If, however, the apparatus is properly balanced and a large expansion tank used, there will be very little trouble from water boiling over.

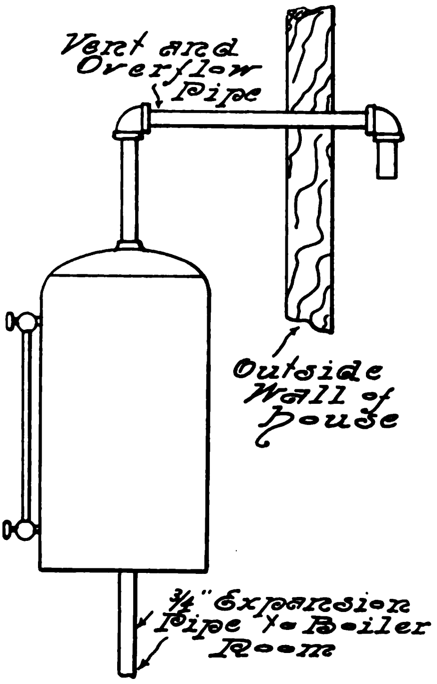


FIG. 130, SKETCH NO. 4—EXPANSION TANK

In Fig. 129 we have shown three risers to the second floor. For the 45-foot radiator we show 1-inch risers; for the 20 and 30-foot radiators ¾-inch risers. These risers are of ample size and will do better work than if they were of larger size. On the 70-foot radiator we would run out to the radiator 1¼-inch and look up through a 1¼ x 1-inch ell, using a 1-inch valve. This 1-inch valve on the radiator will keep it just as hot as though the valve were of a large size. On the 45-foot radiator a 1-inch valve may be used, or the 1-inch pipe may be reduced to ¾-inch where it rises to the radiator, and a ¾-inch valve used, which will do just as good work. On the 50-foot radiator we would use a 1¼-inch horizontal arm, a 1-inch riser and a 1-inch valve. On all of the other radiators we would use ¾-inch valves; where the branch runs out to the radiators 1-inch, use a reducing elbow 1 x ¾.

Our system of piping may look like an innovation to our correspondent, but if he has the courage to install it as we have shown, he will have a perfect working apparatus. Plans of this kind have been used by the writer during the past twenty years, and with marked success. As compared with our correspondent's plan, it will be noticed that we get a more even distribution of heat throughout the house, as both sides of the house will heat at the same time. We then get a drop from the end of each of these 2-inch lines which helps to increase the circulation, and anything that will stimulate the circulation or flow of water through a hot water heating apparatus will decrease the fuel bill, and at the same time increase the efficiency of all the radiators in the house.

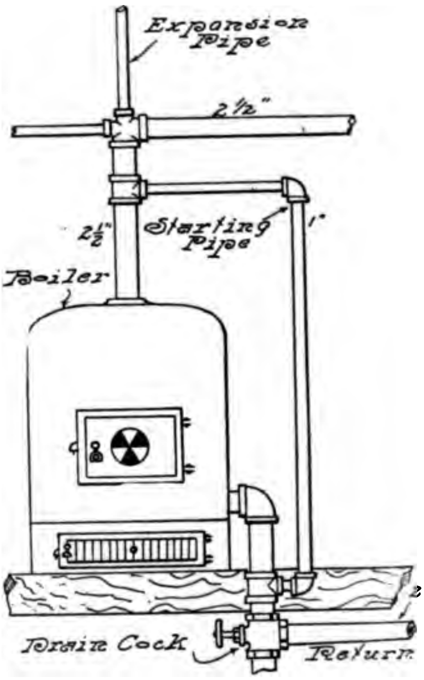


FIG. 131, SKETCH NO. 5—SHOWING DETAIL OF STARTING PIPE, WHERE RETURN RISES TO BOILER IN WATER HEATING

It may not look consistent to use one 2-inch return to receive the water from two 2-inch flow pipes. It is not the usual way of doing, but in practice will give excellent results in this case.

The piping is calculated in this way: One 2-inch pipe will carry all the radiation in the house, but inasmuch as the flow and return water is carried for some distance in the same pipes, we enlarge these pipes and make them 2-inch. When these two pipes and the radiator connections are connected to the 2-inch return, the water in the return will move at a higher velocity and stimulate a circulation of water in the boiler.

The cost for pipe, fittings and labor in our plan will be little more than half of the cost of the same as shown by our correspondent's plan, Fig. 127.

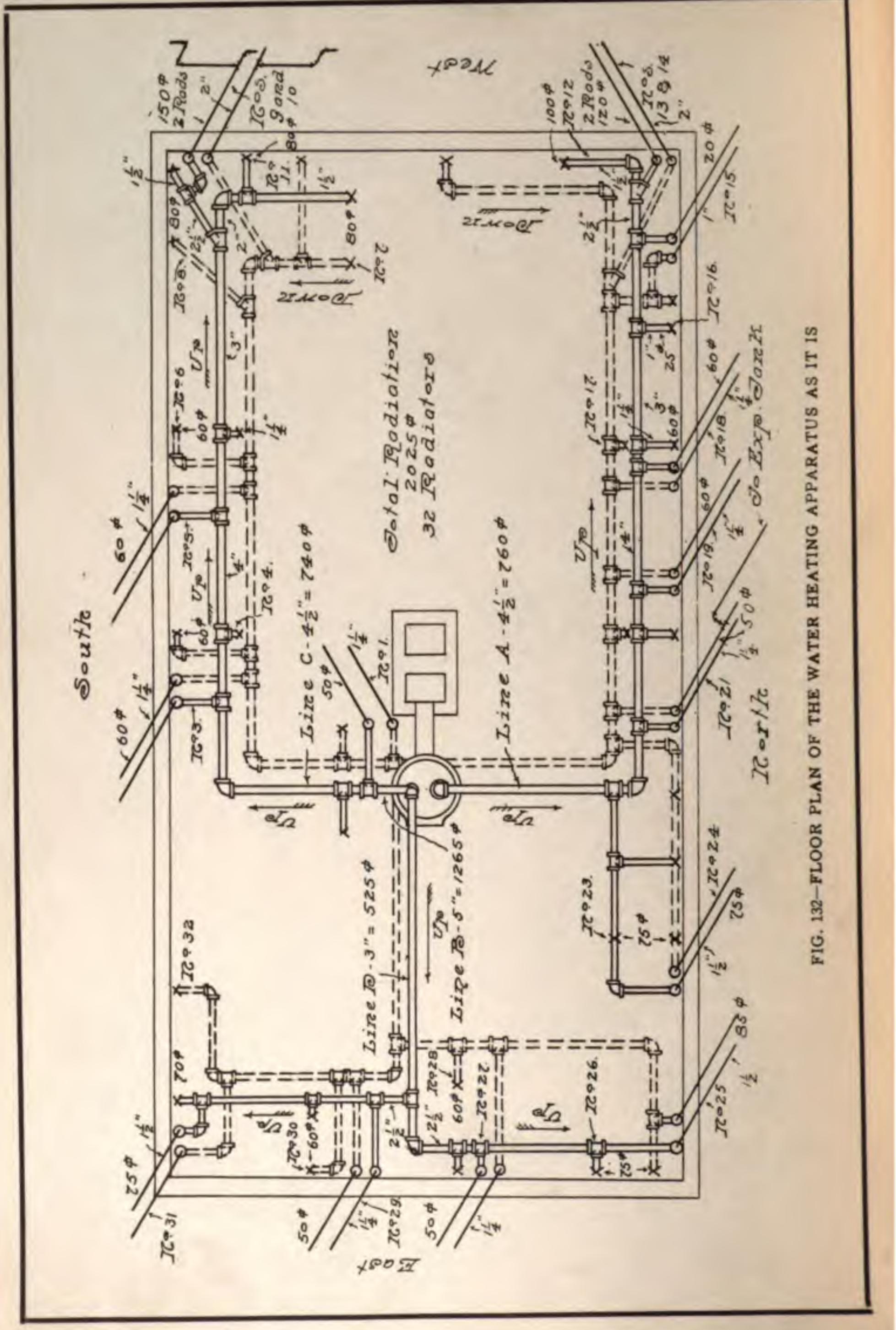


FIG. 132—FLOOR PLAN OF THE WATER HEATING APPARATUS AS IT IS

CHAPTER XXIX.

WATER-HEATING APPARATUS WITH SLUGGISH CIRCULATION—SUGGESTED IMPROVEMENTS.

FIG. 132 represents the basement of a two-story building, 80 x 40, which is warmed by a water-heating apparatus. This apparatus was installed two years ago, but has never been thoroughly satisfactory, due, in part, to the proportion of the pipe and the connections of the return lines.

Riser No. 1, which is close to the boiler, is connected to the return main quite near to the boiler, and as this radiator is connected with a 1¼-inch pipe and valve it heats very rapidly, the water is returned at a high temperature and warms the return column which connects to the bottom of the boiler, weakening the motive power, and, as a consequence, there is trouble with every radiator on that line. The first two or three radiators will heat fairly well when the temperature is very high, but with the ordinary temperature there is scarcely any heat in them. To prove that the No. 1 riser was causing the most of the trouble, it was disconnected and carried to the bottom of the boiler. On firing up there was found to be a decided improvement. The return from No. 2 radiator was then connected to the bottom of the boiler, which still improved matters, and the radiators on this line heat as well as in any other part of the building. There are, however, times when the radiators on the first floor will heat from the return of the radiators on the second floor, and this is due to the fact that the risers are entirely too large. The cooling surface in the mains and risers in this apparatus is about 40 per cent of the radiation, or 800 square feet. The cost of the pipe and fittings on the job was approximately $225, and the labor $200. All practical men will agree that it takes more labor to install large pipe than small sizes. If radiators are all connected with 1½-inch and 1¼-inch valves, and all pipe of equal proportions, the labor per radiator will cost from $1.50 to $2 more than if the radiators are connected with 1-inch and ¾-inch valves, with pipe sizes to correspond.

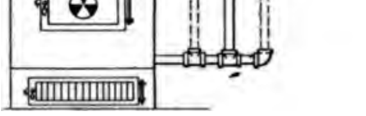


FIG. 133—METHOD OF CONNECTING RETURNS FROM RADIATORS

Fig. 133 shows the method of connecting the returns from radiators No. 1 and No. 2; the dotted lines showing how they were changed to connect to the bottom of the boiler.

In Fig. 134 we show the same basement plan with an improved system of piping. Not only will this give better service, but the pipe and fittings will cost $75 less, and the labor $50 less than if installed as shown in Fig. 165. In this improved system, line "A" is a 4-inch pipe and carries 1,285 square feet of radiation. From this pipe is taken a 2½-inch branch on line "C," which carries 555 feet of

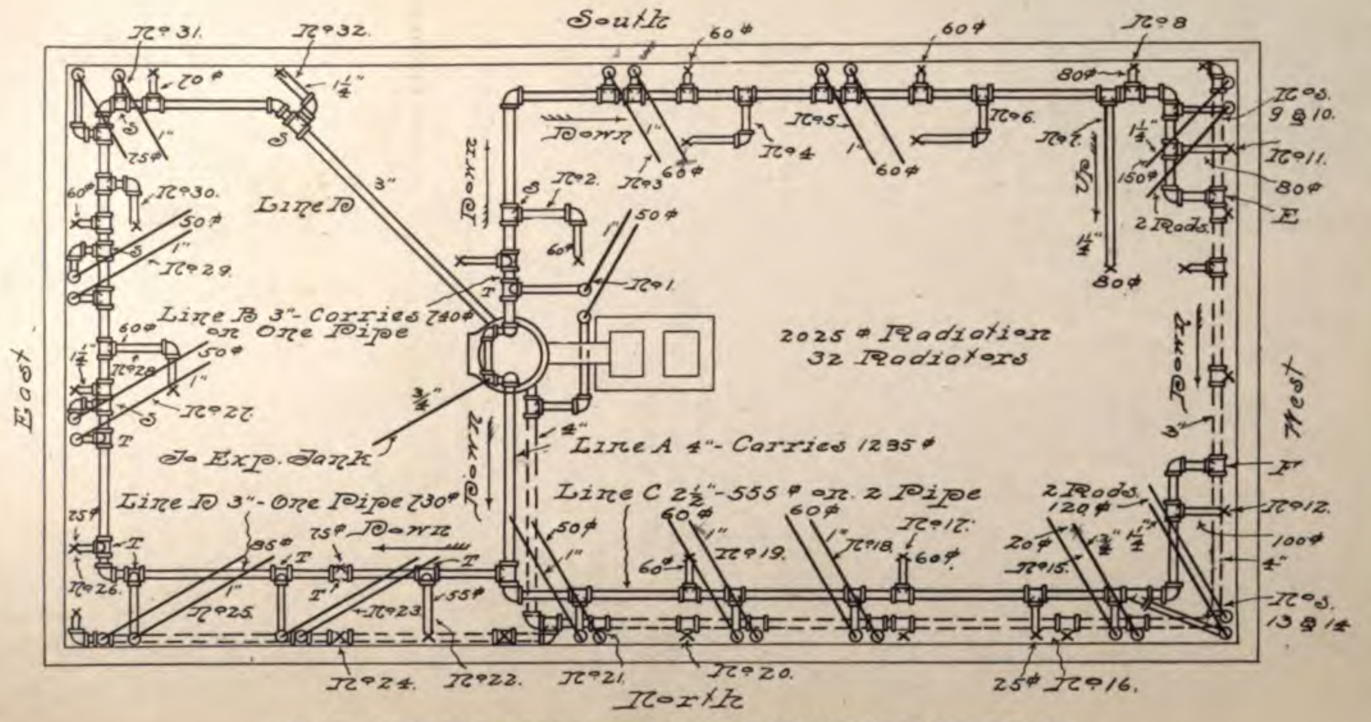


FIG. 134—FLOOR PLAN OF THE WATER HEATING APPARATUS AS IT SHOULD BE

radiation. The connections are taken out of the top of this pipe, and the returns dropped to a point near the basement floor, and are there connected to the return, which is shown by the broken line.

Line "D," consisting of a 3-inch main, is also carried from this 4-inch pipe and takes in the radiation in the northeast corner of the building. The first three connections from this line drop back into a return near the basement floor, but the return from the remainder of the radiators goes into the same pipe, the flow being taken out of the top and the return being taken into the side. Line "B" is a 3-inch pipe, from which the radiators are fed from the top, the returns being taken into the side of the main. This line is carried in the same pipe until the point "E" is reached, where the end of the main drops into the main return, and is carried back to the boiler along the basement wall, near the floor. Lines "A" and "B" pitch down from the boiler, line "A" dropping to the return at "F," and line "B" dropping at "E." This gives excellent circulation throughout the entire system, as the three lines have each their own motive power, which is the difference in weight between the rising and falling column. The high point of lines "A" and "B" are at the boiler and are connected together at the top of the main by a ¾-inch pipe. From this ¾ pipe a line is carried to the expansion tank, which relieves all the pipe in the basement of air. There are people in the heating business, who believe that pipes for water heating apparatus must pitch up from the boiler. This, however, is a fallacy, and an apparatus properly installed, as is shown by Fig. 167 will give much better results, and will cost less than any other basement system. Where a building is three or four stories in height and has attic room, the overhead system will be found still better and less expensive, both in installation and operation.

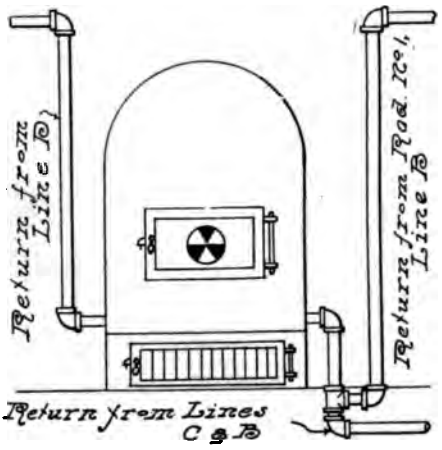


FIG.135—SHOWS RETURNS FROM LINES C B & D

In Fig. 135 is shown the returns from lines "C," "B" and "D." Notice that the return from No. 1 radiator is carried down and connected to the bottom of the rising pipe from the return to boiler. This is done to warm the water in that piece of pipe and start circulation.

CHAPTER XXX.

WATER-HEATING APPARATUS IN NEW ZEALAND.

WE are in receipt of the following communication from one of our subscribers in New Zealand:

We herewith send you a plan of a hot water heating job we have the contract for. We shall be obliged if you will publish same in your valuable journal so that we may get the opinion of your various readers and hot water heating experts. To begin with, the tracing is a copy of the top story and has 24 radiators, the second has 30 radiators, and the ground flat has 18 radiators, in all 72. In the basement we have placed two Daisy boilers connected together, and from them we have run a separate pipe to each flat. We may here state that there is a cellar only large enough to take the boilers. We notice that the plans lately shown in your journal have all the mains carried along through the basements with risers to the several radiators in the different flats. In our case there is no basement, therefore we have supplied each flat with separate mains and branches to the radiators.

Now, what we should be pleased to know is:

1st. What size of mains are required for each flat?

2d. What is the least fall in the mains required to give satisfactory heating results?

3d. What size of radiators is required to heat each room.

4th. Also what heat will be gotten from each radiator with outside temperature at freezing point?

5th. Is it necessary to cover flow and return pipes with asbestos?

6th. Should valves be placed on all pipes coming out of boiler.

By supplying the information asked for and any other that is necessary for the satisfactory working of this system, you will greatly oblige.

Your subscribers,

ANXIOUS.

The tracing of floor plans, Fig. 136, which was sent to us with this communication, represents the third or top floor of the building in which they desire to install a water-heating apparatus. Beyond giving the length and width of the room, the plans give almost no information. The height of the ceiling is not shown, nor is it possible to determine the quantity of external glass and wall through which the rooms will lose their heat. There is nothing to show what the building is to be used for. It may be a club house, or officers' quarters, or the lower floor may be devoted to stores. Had our correspondents furnished us with a complete set of plans showing the different floors, and an elevation, showing the glass exposure and height of ceilings, we could have made them a complete heating plan, which, judging by the letter, would be very acceptable.

We do not understand the idea of running a set of mains around the ceiling of each floor. This would be a most expensive way to do the work, and would spoil the appearance of the rooms. If there is any attic, or room enough for a man to work between the roof and the ceiling joists of the top floor, the proper way to heat this building is by the overhead system.

We can only guess at the radiation, which we place at between 3,000 and 3,600 feet for the entire building. This would give between 1,000 and 1,200 square feet for each floor, and if the pipe can be distributed in the attic, or if not, on the ceiling of the third floor, a 4-inch main running from the boilers to the top, will carry the radiation if it does not exceed four of five thousand square feet.

The second question asked by our subscribers is: What is the least fall of the mains to get satisfactory heating results? All that is necessary to remember in this respect is to run the mains so the water will drain out of them when the system is emptied. It is usual to give the mains a pitch of 1 inch in 10 feet, but it is sufficient to have them run so that they will drain; that is all that is necessary.

The third question is: What size of radiator is required to heat each room? To determine this we must know the cubic contents of the room, the number of square feet of exposed wall, and the number of square feet of exposed glass. As we have not this data, we give here a rule by which our correspondents can figure each room themselves.

We understand the outside temperature will be about 30 degrees, and the inside 65 to 70. We also assume that the building is of fairly good construction and that no special ventilation is provided, so that we will assume that the air in the different rooms will change once per

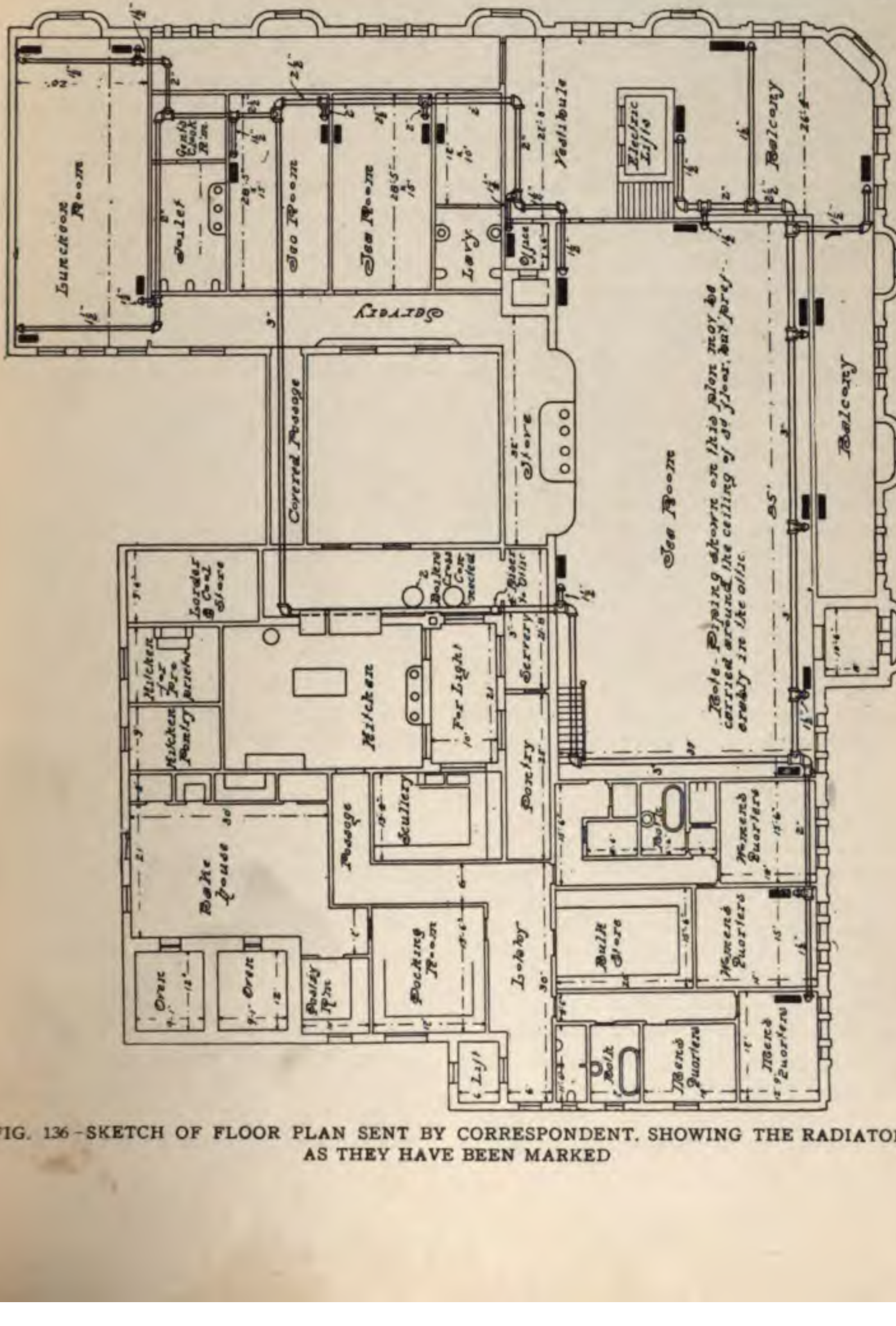


FIG. 136 - SKETCH OF FLOOR PLAN SENT BY CORRESPONDENT, SHOWING THE RADIATORS AS THEY HAVE BEEN MARKED

hour. To the number of square feet of glass in any given room, add one-quarter of the number of square feet of exposed wall surface, and call the sum of the two "equivalent glass surface." Divide this by three, which will show the quantity of radiation required to offset the cooling influence of the glass and wall. Take the cubic contents of the room and divide the same by 200. This will show the quantity of radiation required to warm the incoming air, providing the air does not change oftener than once per hour. If the air changes twice per hour, the cubic contents of the room must be divided by 100, and so on. Consider a room 15 x 15 feet by 10-foot ceiling, with two walls exposed, each outside wall having a window containing 30 square feet of glass and sash. Here we have:

Glass	60 sq. ft.
Wall, 240 ÷ 4 =	60 sq. ft.
Total equivalent glass surface	120 sq. ft.
2½ pounds	8.3 square feet
3 pounds	10 square feet
3½ pounds	11.66 square feet
4 pounds	13.33 square feet

The cubic contents of the room is 2,250 square feet. To obtain the radiation, we divide 120 by 3, which gives us 40 square feet, and dividing 2,250 by 200 gives us 11 square feet, showing that the room will require 51 square feet of radiation to heat it with water under above conditions.

Proceed in this manner with all the rooms on each floor, adding a little radiation to the rooms that are subject to the prevailing winds in cold weather, and taking a little from the sheltered rooms.

The fourth question asked by our correspondents is: What heat will be given off by each radiator with outside temperature at freezing point? To answer this question intelligently we must state that radiation is not affected by the temperature of the outside air, but by the temperature of the air surrounding the radiator. The temperature outside may be zero, while the temperature of the room in which the radiator stands may be 70 degrees. The radiator, therefore, is affected by the air at 70 degrees, and will give off heat accordingly. One square foot of water radiation at a temperature of 170 degrees, and standing in air at 70 degrees, without any special ventilation, will emit about 150 British thermal units per hour.

Fifth question: Is it necessary to cover flow and return pipes with asbestos? If the main are run in the attic, it will be true economy to cover them with asbestos and hair felt, or any other good covering that will prevent loss of heat, and it will also be a good plan to cover the returns if they are under the floors. If, however, the mains are run on the ceiling of a room, it will be as well to use them for heating purposes, and put in as much less radiation as there are square feet in the mains.

Sixth question: Should valves be placed on all pipes coming out of boilers? Valving the flow and return pipes is not at all necessary in water heating. It is frequently done so that in the event of a leak the different sections may be cut out and repairs made without shutting down the entire apparatus. We would like to caution our correspondents in regard to valving flow and return mains. It has happened more than once that where the mains were valved, they were all shut off for some purpose, and then a fire kindled in the boiler without opening them. Under these conditions the expansion of the water will fracture the boilers, and cause a great deal of loss and damage. Wherever valves are put on the mains of a water-heating job there should be a good, reliable safety valve placed between the valves and the boiler. This safety valve should be set at a point 10 or 20 pounds above the static head of water; then if a fire is started in the boilers without opening the valves, the safety valve will give relief and no harm is done.

We reproduce herewith the floor plan, Fig. 136, sent us by our correspondents, showing the radiators as they have marked them. Those which we think are in the wrong location we have crossed out, and show the radiators in other positions.

We show two round boilers, occupying the position indicated on the plans, which we connect together, and run from the cross connection a 4-inch riser to the attic of the building. When this riser reaches the attic a tee 3 x 3 x 4 is connected to end of same, and from this tee two 3-inch lines are run, pitching down to the most remote radiator. From these 3-inch mains, branches are taken out of the side of the main and dropped to the basement or boiler room. The radiators are tapped top and bottom on

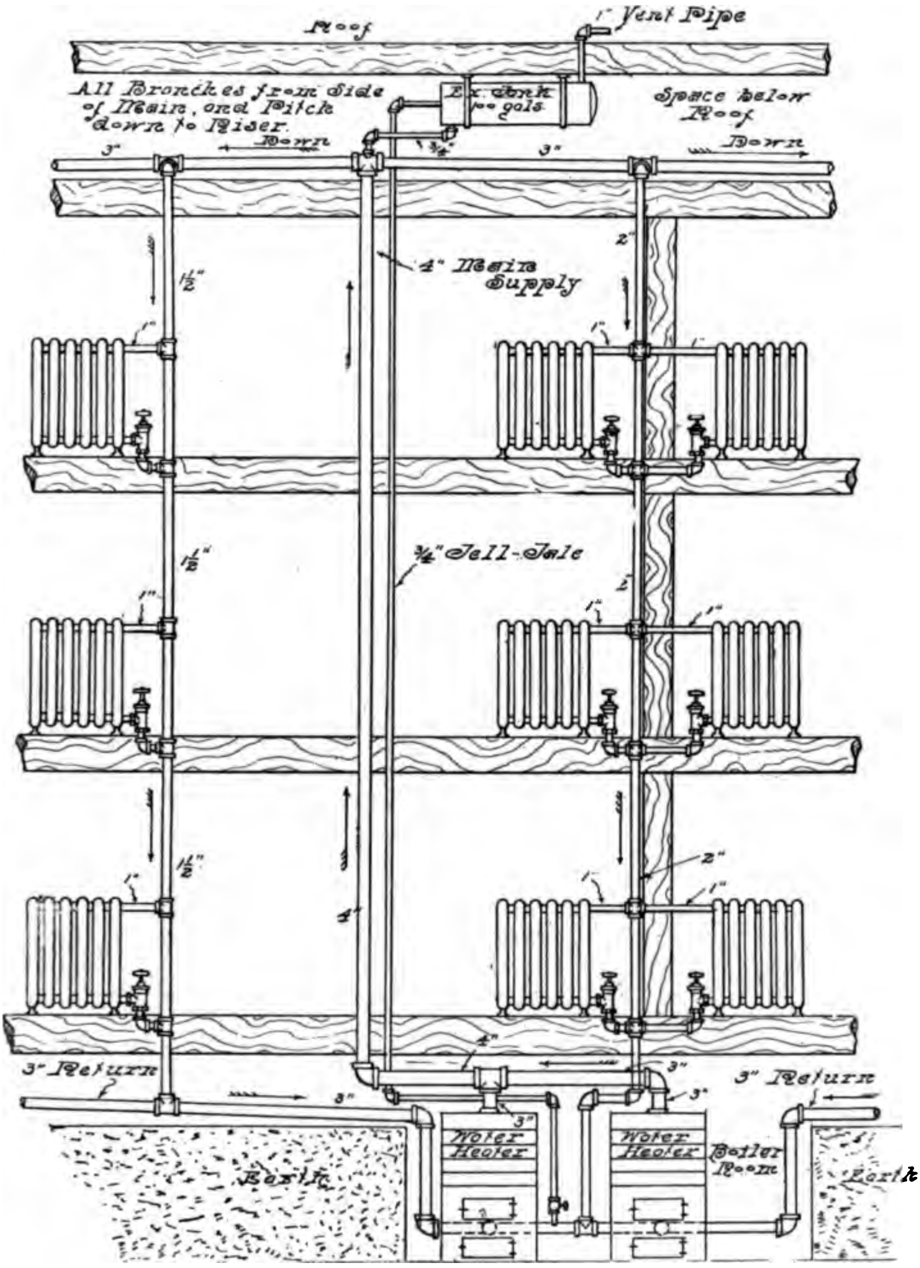


FIG. 137—ELEVATION—ARROWS SHOW THE COURSE OF THE WATER

1

the same end, and are connected up to this single riser, as is shown in the elevation, Fig. 137.

In this elevation are shown two risers dropping from this attic to the basement, one riser is 2 inches and carries six radiators; the other riser is 1½ inches and carries three radiators.

This system is employed very extensively in this country in building of this class, and will always work satisfactorily if properly installed.

To aid our correspondents in determining the size of these drop risers, we will say that for three floors a 1-inch riser will carry three radiators containing 30 square feet each; a 1¼-inch riser will carry three radiators containing 75 square feet each; a 1½-inch riser will carry three radiators containing 100 square feet each; a 2-inch riser will carry six radiators containing 125 square feet each.

If there is no room under the ground floor to run the returns, then these returns will have to be run along the baseboard of the rooms, and the radiators will have to be set up on high legs so that the returns can be connected. We think, however, our correspondents will find no difficulty in getting room for the returns underneath the floors. It will be better to do a little excavating than to attempt to run them in the rooms.

It will be noticed by the elevation plan that the top of the 4-inch riser is the high point. The tee is tapped in the top ¾ inch, and this ¾-inch pipe connected to the bottom of a 100-gallon expansion tank, which is shown on its side, as we assume that there would not be room in the attic to use the tank in a vertical position. From about the center of this tank a ¾-inch tell-tale pipe is carried back to the boiler room and equipped with a valve. In filling the apparatus the water is allowed to run until it shows in the tell-tale pipe. The water is then shut off and the apparatus will be found full of water up to the center of the expansion tank. A fire may then be started, and as the water expands in the system it may fill the expansion tank, and any surplus will be carried out through the vent pipe, which is shown carried up through the roof. It will, of course, be necessary in this system to have the water above the mains in the attic, otherwise the system will not heat.

As our correspondents probably know, a system of this kind does not require any air valves, all the air being carried up and into the expansion tank. In connecting the radiators from the riser, it is best to arrange to take the connection off the side of the tee, so as to have a swing joint. Where two radiators are connected a cross may be used. For the returns it is better, where it can be done, to place the tee or cross below the floor and look up to the radiator, placing the controlling valve on the return line. Of course, the valve may be placed on the flow pipe, at the top of the radiator, but it does not look as well. Our correspondents must bear in mind that a 3 x 3 x 4 tee on top of the 4-inch riser is the hign point of the system, and from that everything must fall slightly toward the boiler, so that the water will drain out of it when the system is empty.

When the branches for the risers are taken out of the main they must come out of the side. If they were carried off the top, an air trap would be formed and no water would pass.

The return mains in the basement correspond in size with the flow pipes in the attic.

For full details of the overhead system, see Chapters VII. and VIII., where are shown plans of successful working jobs.

CHAPTER XXXI.

RELATIVE VALUE OF HEATING SURFACE IN BOILERS—SIZE OF CHIMNEY FLUES.

IN selecting a boiler for house-heating purposes, it is not always safe to rely on the ratings in the various boiler catalogues, for this reason: A boiler that will work up to its full rated capacity under one set of conditions may be an utter failure in another installation, although the load on the boiler under both sets of conditions may be exactly the same. This applies more particularly to boilers which have a large amount of flue surface and a long fire travel. Such boilers will only do their best where there is a very strong draft; when attached to a chimney where the draft is indifferent they may not carry half the load assigned to them in the catalogue.

The reason for this is that every pound of coal burned requires for its perfect combustion a quantity of air, which may be stated, theoretically, as 150 cubic feet. In practice, however, the amount required for good combustion will run from 50 to 100 per cent more than the theoretical quantity. When, however, there is an insufficient supply of air, the coal will burn away just as rapidly, but will yield much less heat than when there is a sufficient quantity of air.

To put the matter plainly: Each atom of carbon requires for its perfect combustion two atoms of oxygen, and when the carbon combines with this quantity of oxygen it burns to carbon dioxide and yields per pound 14,500 heat units. If, however, through an insufficient air supply there is less than two atoms of oxygen to one of carbon, the carbon will then combine with but one atom of oxygen, and will burn to carbon monoxide, yielding 4,500 heat units, or less than one-third the heat given off where the combustion is perfect.

Now, when a boiler with long fire travel is attached to a chimney flue of scant size, the gases cool before entering the chimney and the velocity of the rising column of air is not sufficient to pull enough air into the mass of fuel to promote good combustion.

A boiler with a direct draft will deliver the gases into the chimney at a higher temperature, which will increase the velocity of the draft and cause an increase in the flow of air through the fuel, giving better combustion and higher efficiency.

This will explain the reason that in some installations a boiler may burn a large amount of coal with very low heating effect. Thomas Box, in his "Treatise on Heat," page 82, paragraph 111, in speaking of the effect of an insufficient air supply, says: "This will explain the anomalous fact that where there is a bad draft, not only is there difficulty in keeping up the steam, etc., but that there is a great consumption of fuel for the work done. It might be expected that with a dull, slow fire, few coals would be burned, or if, by dint of forcing, fuel was largely consumed, it must yield the heat due to it, but it will be evident that it is possible for there to be a dull fire, a large consumption of fuel, and little useful result at one and the same time, and all this arising from insufficient draft."

In installations where there is any doubt about the draft, it is always good practice to select a heater that has a short fire travel and direct heating surfaces. The draft, or rate of combustion in this direct draft boiler can be controlled by a good cross damper in the smoke pipe and under these conditions better fuel economy can be obtained than where an attempt is made to retain all the heat in the boiler, which is, of course, an impossibility. As a matter of fact, it is impossible to get good combustion in fuel or expect it to yield a high calorific power unless there is sufficient heat in the chimney flue to produce an intensity of draft sufficient to draw the necessary amount of air into the bed of fuel. Of course, it is generally understood that the draft in a chimney is caused by the difference in the weight of two columns of air. The greater the difference in temperature between the column of air in the chimney and the outside temperature the greater will be the weight between the two columns and the higher will be the velocity of air within the flue.

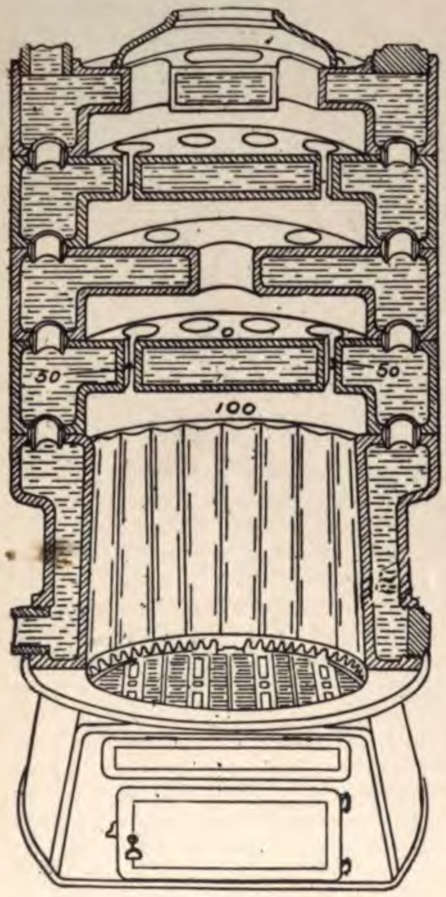


FIGURE 138

Experiments made in recent years show that in house-heating boilers a temperature of from 350 to 500 degrees F. in the smoke pipe will give a greater economy per pound of fuel than will a temperature below 300. The difference, however, is not so great as many people suppose. The ordinary householder, in running his boiler in the fall and spring, finds that the fire will last from twelve to twenty-four hours without attention, and possibly longer. He, therefore, concludes that if he can get a boiler with slow combustion he is going to save an immense amount of fuel, overlooking the fact entirely that in mild weather, when he is burning a small amount of fuel, the boiler is doing scarcely any work; in other words, he has no means of measuring the unit of work against the unit of fuel.

The best that can be obtained from a pound of anthracite coal in practice is about 75 per cent of its heating power, and at this rate one pound of anthracite coal will tak ecare of 3.75 square feet of steam radiation at two pounds pressure for eight hours; that is, it will maintain a temperature of 218 degrees in 3.75 square feet of radiation per hour for eight continuous hours when the temperature of the air surrounding the radiator is 70 degrees. Where the temperature of the smoke pipe is about the same as that of the steam, or say 218 degrees, the water will absorb a lower percentage of the calorific power of the fuel, because the combustion will not be so good.

In regard to the various kinds of heating surfaces, it is, of course, a well-known fact that horizontal surfaces, directly over the fire, will transmit heat more rapidly than when placed in a vertical position or at any other angle, but it must be borne in mind that while this is true, such direct horizontal surface is limited to the first section over the fire pot, which masks everything above it. The manufacturers of boilers are gradually coming around to this view of the matter, and modern builders are making their boilers with either vertical surfaces, or, where horizontal surface is used, the gas passages are made very large so that the upper sections receive a greater proportion of the radiant heat than is possible where the flues are just large enough for the volume of gases to escape. There are many boilers on the market whose gas passages or flues are entirely too small. The gases in passing through these narrow flues cool very rapidly and the heating surfaces of the boiler which are far removed from the fire are of little or no use; in fact, there are boilers in which the value of the heating surface near the smoke pipe is a minus quantity, giving off the heat of the water or steam to the gases instead of receiving heat from them.

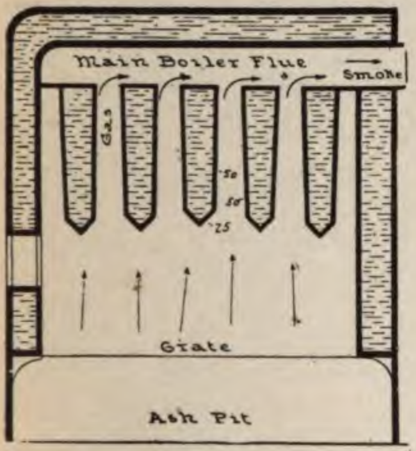


FIGURE 139

Fig. 25 represents a section through the horizontal heating sections of a round boiler. The value of the under side, which is next to the fire, is 100; the flues or gas passages through the section is 50 and the top of the section is 0. The reason that the top of the section has no value as heating surface is, first, because it is masked from the fire; second, the water in the top of the section receives its heat from the bottom and will not conduct heat to the lower strata because water is a poor conductor of heat; and third, because there is usually a film of soot on the upper surface of the sections, which is a good non-conductor.

The sections above section No. 1 receive very much less heat than is generally supposed. If the gas flues are proportionate to the volume of the gases only, the second section will transmit less than half as much heat as will the one below it, and if there are enough sections to retard the draft and kill combustion, the boiler will not work until enough of the top sections are taken off to permit a free flow of the gases.

Fig. No. 139 represents a section through vertical heating surfaces, in a square section boiler. While this vertical surface is on a plane with the rising gases and its value is 50, as against 100 for flat surface, at right angles with the escaping gases and directly over the fire, yet the quantity which can be presented to the direct rays of the fire is limited only by the size of the boiler. Then, again, the water in the vertical surfaces has a greater capacity for absorbing or carrying off the heat of the fire than is possible in horizontal surfaces, because in the vertical surface the water moves rapidly, and the more rapid the movement of water in a boiler the greater is its heat-absorbing capacity.

Figs. Nos. 140, 141 and 142 are copied from Box on heat, and show the effective heating surface of the various forms when exposed to the fire. The fire being on the lower side of the figures, the flow of the radiant heat is in an upward direction.

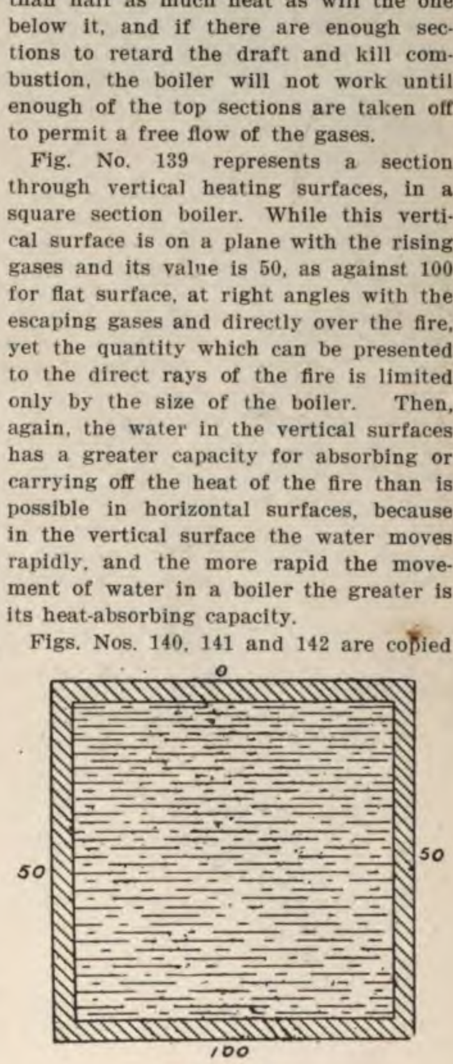


FIGURE 140

In all these figures Box considers the top surface of no value for the transmission of heat.

In domestic steam boilers in practice, a square foot of heating surface will evaporate from 2 to 6 pounds of water per hour, according to the position of the heating surface and the rate of combustion. If the evaporation is but 2 pounds per square foot per hour, one square foot will care for 6.66 square feet of radiation at 2 pounds initial pressure.

2½ pounds	8.3 square feet
3 pounds	10 square feet
3½ pounds	11.66 square feet
4 pounds	13.33 square feet
5 pounds	16.66 square feet
6 pounds	20.00 square feet

Boilers with very direct draft can be forced to evaporate as high as 8 pounds per square foot per hour, but at the expense of the fuel. Domestic boilers should be so constructed that they will evaporate from 3½ to 5 pounds of water per square foot of heating surface per hour, without undue forcing.

It is not the intention here to write a treatise on boiler designing or to give advice to boiler manufacturers, but to suggest to the inexperienced fitter how to avoid the trouble incident to selecting the wrong kind of boiler for a given installation.

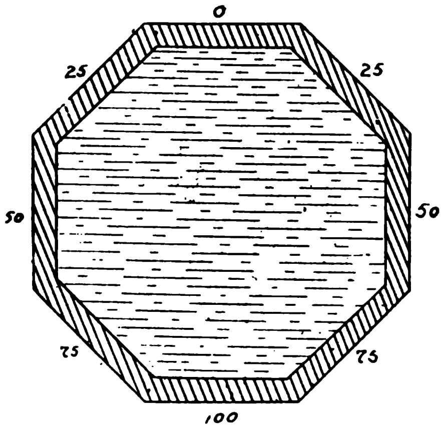


FIGURE 141

The value of good combustion cannot be too strongly emphasized, and without a strong draft and a hot fire box, the fuel will burn away and yield a low percentage of its heating power. Considering the fact that coal, burning to perfect combustion, will yield three times as much heat as when through a lack of oxygen the combustion is at its worst, we must see the importance of selecting a boiler that will not be handicapped by having a long, narrow and tortuous fire or gas gravel. To sum up, boilers with more than 50 per cent. of fire or indirect surface, should only be attached to a chimney flue of such proportions as will insure a strong draft. The question will naturally arise, "How am I to know when the flue is of ample size to insure good draft?"

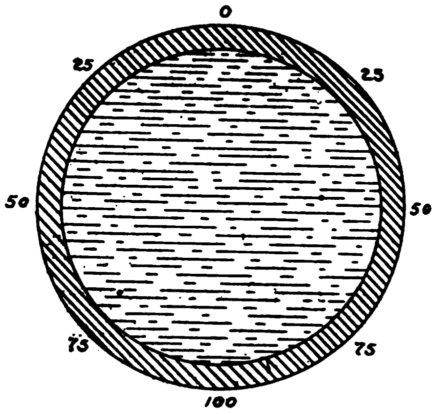


FIGURE 142

The following table of sizes is a safe guide to follow, and where the flue is much below these requirements, select the boiler with the most direct draft that can be found:

Steam radiation.	Water radiation.	Height of chimney.	Size sq. chimney inside.
300	450	35	8 x 8
600	900	35	8 x 12
900	1350	40	8 x 12
1200	1800	40	12 x 12
1500	2250	40	12 x 12
1800	2700	50	12 x 12
2100	3150	50	14 x 14
2400	3600	50	14 x 14
2700	4050	50	16 x 16
3000	4500	60	16 x 16
4000	6000	60	20 x 20
5000	7500	60	20 x 20
6000	9000	60	24 x 24

It is a fact that a round chimney 12 inches in diameter is as effective as one

12 x 12 inches, although the area of the round chimney is 113 square inches, while the square one is 144 square inches.

It is understood, of course, that in specifying the height of a chimney, the top must be above that of the surrounding roof tops and there must be no other openings in the flue to admit air. Every cubic foot of air that enters the chimney without first passing through the grates of the boiler cools the escaping gases and weakens the draft.

CHAPTER XXXII.

BOILER CAPACITIES AND FUEL CONSUMPTION.

As the majority of the house heating boilers on the market are used for both steam and water heating, it is usual to ascertain by evaporative tests what the steam boiler will do, and to the capacity of the steam boiler add 65 per cent. for the water heating capacity.

This is a somewhat arbitrary rule and is based on the assumption that one square foot of steam radiation at a temperature of 219 degrees Fahr. will emit or give off 293 heat units, when the surrounding air is 70 degrees, and that one square foot of water radiation at a temperature of 170 degrees will emit 177 heat units with the surrounding air at 70 degrees. The temperature difference between the steam radiation (219 degrees) and the air (70 degrees) is 149 degrees and 293 heat units per square foot per hour is equal to 1.966 heat units emitted per square foot per hour per degree of difference between the temperature of the radiator and the temperature of the surrounding air.

The temperature difference between the water radiator (170 degrees) and air (70 degrees) is 100 degrees, and 177 heat units emitted per square foot per hour is equal to 1.77 heat units emitted per square foot per degree of difference.

The leading authorities of the present day are agreed that one square foot of radiation at 220 degrees standing in air at 70 degrees will condense from 0.25 to 0.3 pounds of steam per hour, the latter figures being equal to an emission of 289.8 heat units per hour and per square foot per hour per degree of difference is equal to 0.002 pounds of steam or 1.932 heat units. Now, as the temperature difference between the water radiator at 170 degrees and the air at 70 degree is 100 degrees, the water radiator will emit 193.2 heat units per square foot per hour as against 289.8 heat units per hour for the steam radiator—a difference of 50 per cent.

As a matter of fact radiators are not all of the same efficiency, and it is not possible to say exactly what the rate of condensation is, but for the purpose of computing boiler power required it is safe to figure .002 pounds condensation per square foot per hour per degree of difference, which, as we have shown, is equal to 1.932 heat units. To facilitate calculation, we will call the latter 2 heat units, and present the following table which shows the percentage of difference between water and steam radiation at different temperatures, the surrounding air being 70 degrees:

Temperature of Steam Radiation.	Temperature of Water Radiation.	Increase of Water Over Steam. Per Cent.
220	180	36.3
220	170	50
220	160	66.6
220	150	87.5
220	145	100
212	180	29
212	170	42
212	160	57.7
212	150	77
212	145	89.3

This per cent. of increase applies to boilers as well as radiators. In very cold weather the steam radiation will often be at a temperature of 220 degrees, and if we could be sure of a temperature in the water radiator of 170 degrees, then but 50 per cent. increase would be required, but, owing to the various methods of piping, the loss of heat in a water heating job, between the boiler and the radiator, is not easily computed and is frequently much greater than it should be. It is, therefore, good practice to figure for the coldest weather an average of 220 degrees in steam radiation and 165 for water—or 60 per cent. difference.

The highest type of house heating boiler will evaporate on an average nine pounds of water per pound of anthracite coal.

To ascertain the capacity of a steam boiler we must know how much water it will evaporate per hour and by dividing that amount by the rate of condensation per square foot of radiation we arrive at the number of square feet of radiation the boiler will carry.

Suppose the boiler will evaporate 180 pounds per hour. Dividing by .3 gives 600 square feet; 240 pounds per hour 800 square feet; 900 pounds per hour 3,000 square feet, etc.

Now, if a given boiler evaporates 80 pounds of water per hour and burns one pound of coal for every seven pounds evaporated, there will be required 25.7 pounds of coal to take care of 600 square feet of radiation for one hour. If the boiler evaporates 8 pounds of water per pound of coal burned, there will be required to carry the 600 square feet of radiation one hour 22.5 pounds, and if 9 pounds of water are evaporated per pound of coal but 20 pounds will be consumed.

In placing the radiation in a house we figure for enough to warm the rooms to 70 degrees in the coldest winter weather, and the boiler should be large enough to maintain the required temperature in the radiators for eight hours without attention.

We have shown that the most efficient boilers will consume in the coldest weather 20 pounds of coal to maintain a temperature of 220 degrees in 600 square feet of radiation for one hour. Then for eight hours there would be required 20 × 8 = 160 pounds, and at the end of eight hours we must have enough live coals to ignite a fresh charge of fuel. Experience teaches us that this reserve is equal to 25 per cent. of the fuel required for consumption—in this case 40 pounds—which makes the proper hard coal capacity for a 600 square foot house heating steam boiler 200 pounds. If a 600 feet boiler will evaporate only 8 pounds of water per pound of coal, the fuel capacity must be 225 pounds, while 7 pounds of water per pound of coal will require a fuel capacity of 257 pounds.

The accompanying diagram, Fig. 143, represents a graphical method of ascertaining, without the labor of figuring, the quantity of coal required to do a given amount of work. The diagonal lines are the lines of efficiency based on the percentage of calorific or heating power of the coal utilized by the boiler.

Do not confound this with the efficiency based on the combustible of the fuel, as there is quite a difference. We use coal efficiency because it is more easily understood.

The calorific power of anthracite coal is taken at 12,000 heat units, which is about all a pound of the average coal will yield in house heating work.

Seven pounds of water evaporated from and at 212 degrees Faht. is equivalent to 6,762 British thermal units, or 56.3 per cent. of the calorific power. Eight pounds equal 7,728 heat units or 64.4 per cent. Nine pounds equal 8,694 heat units or 72.4 per cent. Nine and a half pounds equal 9,177 heat units or 76.5 per cent.

The diagonal lines, numbered 1, 2, 3, 4, are for steam radiation running at 220 degrees temperature in 70 degrees of air for eight hours without attention.

Line 1 represents an evaporative power of 6.73 pounds per pound of coal; line 2, 7.73 pounds; line 3, 8.73 pounds; line 4, 9.17 pounds.

The diagonal lines, numbered 5, 6, 7, 8, are the corresponding lines for water radiation running at 170 degrees for eight hours.

Line 5 represents 6,500 B. T. U. utilized per pound of coal; line 6, 7,500 B. T. U.; line 7, 8,400 B. T. U.; line 8, 8,800 B. T. U.

Each horizontal line represents four square feet of radiation, and each vertical line one pound of coal.

Suppose it is desired to know the size boiler necessary to carry 1,300 square feet of steam radiation at 220 degrees for eight hours on one coaling without attention to fire.

Selecting a boiler of the best type we use the diagonal line No. 3 and find that 100 pounds of coal will carry 362 square feet of radiation—300 pounds will carry 1,086 feet, leaving 214 feet of radiation, the line of which intersects diagonal line No. 3 at the vertical line representing 59 pounds of coal. We, therefore, require 359 pounds of coal plus 25 per cent., or a total coal capacity of 448 pounds to provide for maintaining 1,300 square feet of radiation at a temperature of 220 degrees for eight hours without attention to the fire.

As the diagonal lines representing water heating do not run so high as 100 pounds of coal, we can use the vertical line representing 50 pounds.

It may be well to state that the amount of coal required to do a measured amount of work has no relation to the quantity of coal required for a full heating season, because it is seldom that every square foot of radiation is in commission for any sustained period.

It is usual to calculate roughly that 100 square feet of steam radiation will require three tons of anthracite coal, or four and one-half tons good soft coal, for the heating season of 200 days, and in water heating from one and a quarter to one

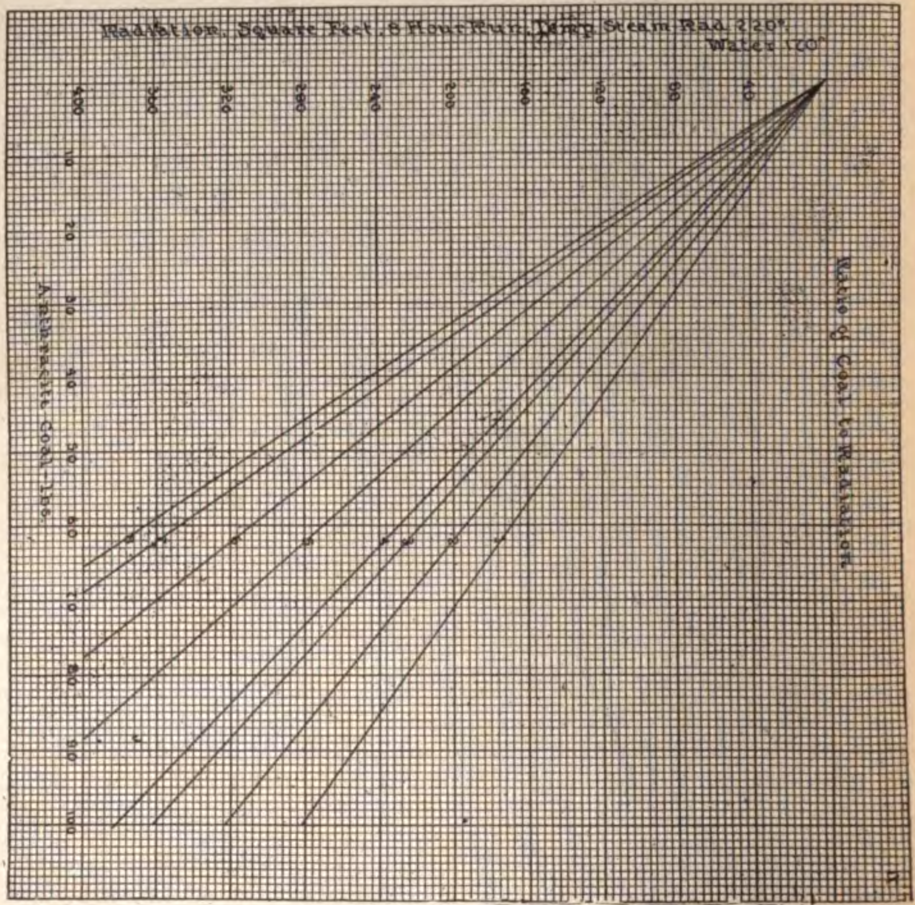


FIG. 143—GRAPHICAL METHOD OF ASCERTAINING WITHOUT LABOR OF FIGURING, THE QUANTITY OF COAL REQUIRED TO DO A GIVEN AMOUNT OF WORK

and one-half tons per 100 square feet of radiation per season. Thus, 1,300 feet of steam radiation will require approximately 39 tons of anthracite coal or 59 tons of soft coal for the heating season.

If, however, it were possible to run the apparatus every hour of the 200 days at a temperature of 220 deg. in the radiation and the surrounding air 70 deg., the coal consumption would be 107.5 tons.

CHAPTER XXXIII.

BOILER CAPACITIES AND FUEL CONSUMPTION.

IN Chapter XXXII. we presented a diagram of the relation of coal to radiation based on a run of eight hours. We now show in Fig. 144 a diagram based on a six-hour run, which, of course, shows an increase of radiation per pound of coal.

This system of rating boilers must not be carried to extremes in either direction. For example, if a boiler will carry 600 square feet of radiation for eight hours on one charge of fuel, it does not follow that it would carry 1,200 feet for four hours, or 2,400 feet for 2 hours, because the coal could not be burned at that rate. It is, however, safe to figure that a boiler with direct draft can be so run as to take all the way from five to ten hours to burn its charge of coal.

Many boilers do their best work and

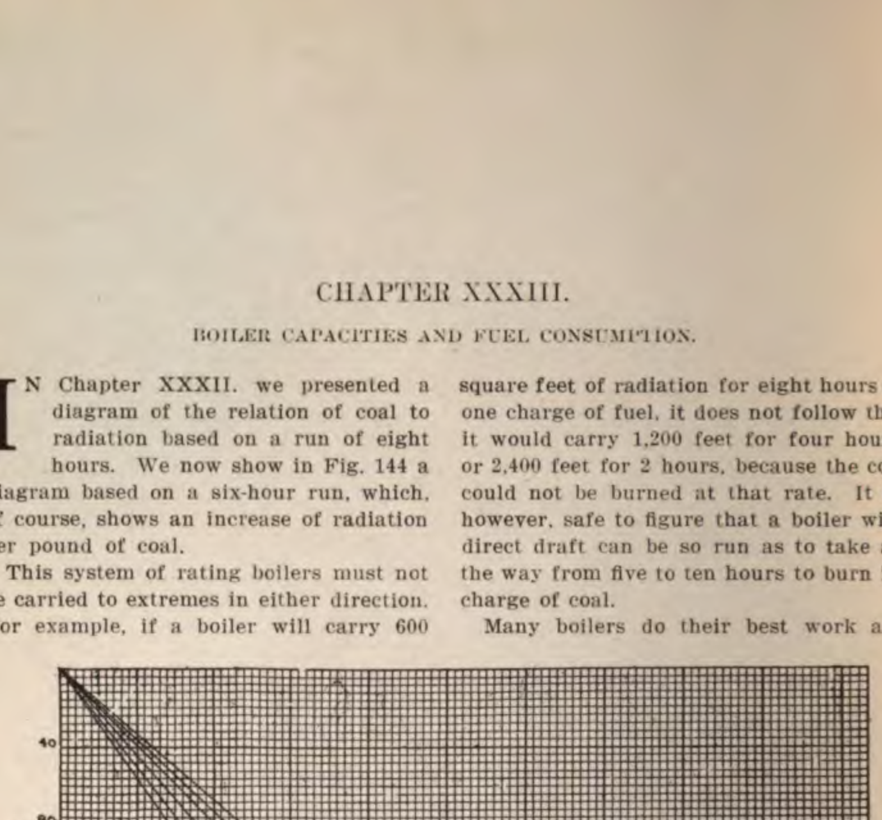


FIG. 144—QUANTITY OF COAL REQUIRED TO HEAT A GIVEN AMOUNT OF RADIATION TO 229 DEGREES FOR 6 HOURS

show the greatest economy of fuel when the gases are leaving the boiler at about 375 to 500 degrees F. When the gases leave the boiler at temperature of 700 degrees, there is some waste of fuel, but not so much as the high temperature would indicate because of the increased yield of heat due to good combustion.

If a boiler is rated to carry 800 feet of steam and if in burning the fuel it absorbs or utilizes 8,500 heat units from each pound of coal burned, there would be required 28.2 pounds of coal per hour; and if the fire pot of boiler held but 150 pounds, deducting 20 per cent. for the recoaling reserve, would leave but 120

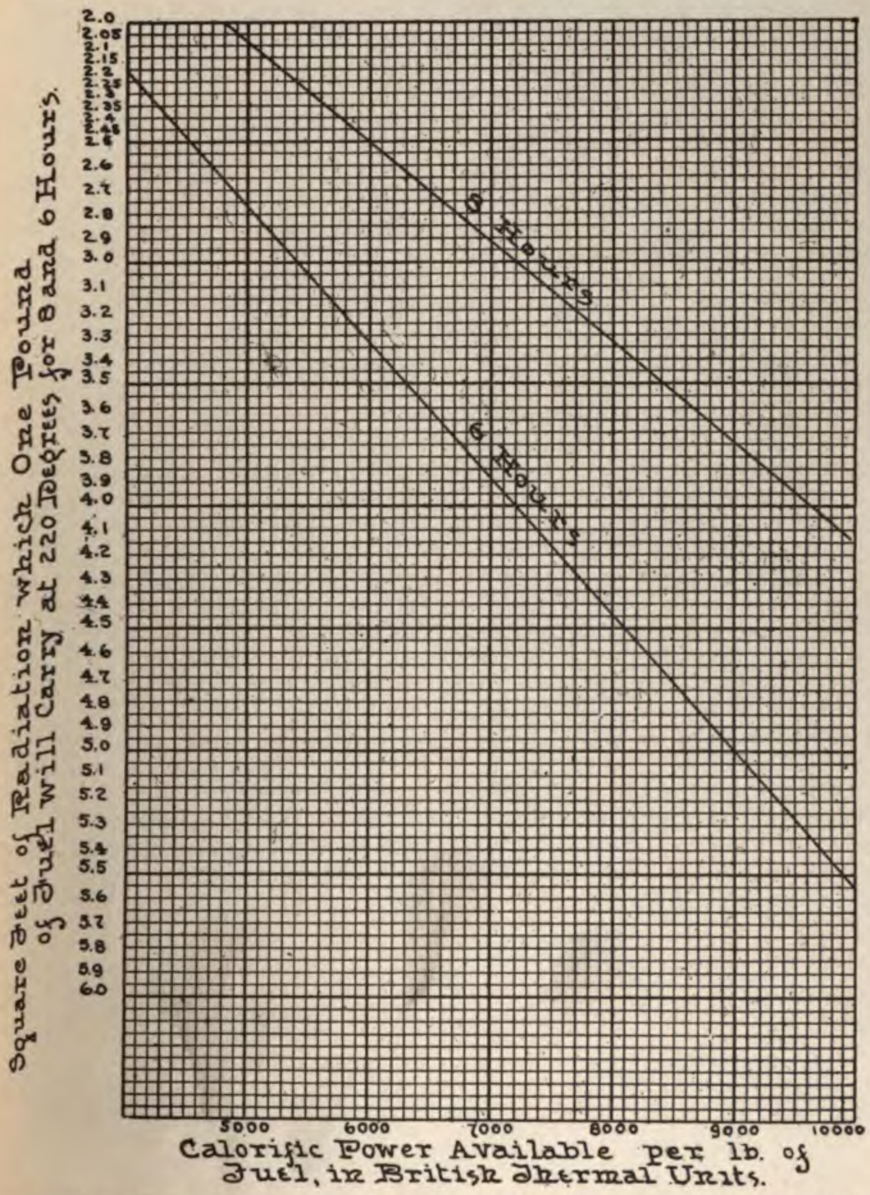


FIG. 145—GRAPHIC CHART SHOWING RATIO OF RADIATION TO ONE POUND OF COAL

pounds available, which would last but 4½ hours. To carry the 800 feet of steam radiation for eight hours at 220 degrees temperature and 70 degrees air, would require, under the conditions named, a hard coal capacity of 282 pounds.

If the boiler utilizes 9,000 heat units per pound of coal, there will be required 26.66 pounds per hour to supply 800 square feet of radiation, or 213.28 pounds for eight hours, to which we must add 25 per cent. for a reserve, making the required fire pot capacity 266.6 pounds.

If 9,500 heat units are utilized per pound of coal, the hourly consumption will be 25.2 pounds, or 201.6 pounds for eight hours or a fire capacity of 252 pounds. These figures are obtained by assuming that a square foot of radiation at 220 degrees in air at 70 degrees will lose 300 heat units per hour, then 800 square feet will lose 800 x 300 or 240,000 heat units per hour. If each pound of coal gives off to the water in the boiler 9,000 heat units we divide 240,000 by 9,000 to see how many pounds of coal is required per hour. This we find to be 26.66 pounds. Mutiplying this by 8 gives 213.28 pounds of coal burned in eight hours, and when we add 25 per cent. for a recoaling reserve we find the coal capacity of the boiler must be 266.6 pounds to be exact.

Now, as we have assumed a high efficiency for the radiation and have also assumed that it will be in full commission every minute of the eight hours, it follows that radiation of less efficiency, or where all of the 800 feet is not in active operation, there will be less coal required. In Fig. 32 we show by diagram the amount of radiation in square feet which one pound of coal will take care of when burned in boilers at different calorific powers available.

Where the power available, that is, where the power of the fuel utilized by the boiler, is 6,000 heat units, one pound of fuel will take care of 2.5 square feet of radiation for eight hours If 9,000 heat units are utilized, one pound of fuel will take care of 3.75 square feet, a difference of 50 per cent.

The point of all this is that there are boilers on the market to-day that will actually utilize but 50 per cent. of the calorific power of the fuel, or 6,000 heat units per pound of coal, while others will utilize 9,000 heat units, and yet the trade pay exactly the same price for the two types of boilers because they do not know the difference.

If the trade should insist that the manufacturers furnish them with the fuel capacity and the quantity of water in pounds that each boiler will evaporate per pound of fuel when run for eight hours on one filling, there would soon be a weeding out of the inefficient boilers, and the complaints of over-rating would cease.

To use the diagram, Fig. 145, it is necessary to know about what degree of efficiency to look for in boilers. We therefore take the vertical line 8,000 as the average, 9,000 as high, and 6,000 as very low.

For hard coal it will be a fair average to assume 8,000 to 8,500 for well proportioned boilers burning hard coal, and for soft coal between 6,000 and 7,000 will be very close to the average results observed in actual practice.

CHAPTER XXXIV.

COKE-BURNING BOILER.

FUEL.—The calorific power or heating value of any fuel is measured by the number of British thermal units which its combustion will generate, one British thermal unit being the quantity of heat required to raise one pound of water through one degree Fahrenheit.

Combustible is that portion of the fuel which will burn. The ash, slate, silica, etc., will vary in different fuels anywhere from 2 to 35 per cent.

All the fuels used for generating steam depend for their heating value upon the percentages they contain of the two chemical elements, carbon and hydrogen. Solid fuels, such as coal and wood, contain, in addition to these two elements, other substances which have no heating value, such as ash, water and oxygen, the oxygen being in chemical combination with the hydrogen and carbon. Most coals contain also small percentages of sulphur, and when a coal has a high percentage of sulphur it usually results in clinkers.

Liquid fuels, such as petroleum and its products are nearly pure compounds of carbon and hydrogen, and gaseous fuels contain carbonic oxide, hydrocarbon gases and hydrogen as their heat-giving substances.

The heating power of the fuels in general use is shown in table A, page 156.

In this table will be found under column 1 volatile matter; column 2, the fixed carbon; column 3, ash; column 4, the theoretical heating power as obtained in the laboratory by use of a calorimeter; and in column 5 the highest available heating power which we may expect from fuels when burned in the best type of house-heating boilers where there is good combustion.

The heating values in the table are only a close approximate, because it is impossible to prepare any table on coal values and have it strictly accurate. A table could be prepared showing the exact heating value of the combustible of any fuel, because the heating power of the combustible of the various fuels is nearly constant, but in the coal itself it necessarily varies because of the varying percentages of ash and other incombustible.

In anthracite coal we give the average of the different coal fields, placing the theoretical heating value at 13,200 B. T. U., and the highest available heating power obtained from practical use in house heating boilers at 9,000 B. T. U.

We note that the volatile matter in anthracite coal will average four per cent., while the fixed carbon is 85 per cent, and the ash .5 per cent. Egg coal gives a higher percentage of fixed carbon than does the average of smaller sizes, while pea coal gives only 79 per cent. of fixed carbon and has 15 per cent. of ash.

The semi-bituminous coals have a higher theoretical heating power than has anthracite coal, and were it not for the excess of volatile matter over anthracite, they would be the best possible coals to use in house heating boilers, but as this volatile matter is liberated at a comparatively low temperature, it very frequently escapes without being ignited, leaving nothing but the fixed carbon of the fuel to do the work.

The available heating power of the semi-bituminous coals is 8,500 B. T. U., which can be realized if the coal is burned in a well-constructed house heating boiler with a good draft in the chimney flue. These coals would not show as high an available heating power were it not for the fact that they fuse under heat and form a crust over the top of the fuel, which retards the escape of the volatile gases, a portion of which combined with oxygen is ignited and utilized. This is very noticeable in the bituminous caking coals. Turning to Table A, we see that while there is very little difference in the theoretical heating power of the caking and non-caking bituminous coals, there is a wide difference in available power when the fuels are burned in house-heating apparatus. The caking coal fuses and forms a crust, as has just been described, while the non-caking coal falls apart and burns very much like charcoal, permitting the valuable gases to escape at a comparatively low temperature unignited, for want of oxygen with which to combine, resulting in a heavy loss in heating effect, leaving us only the fixed carbon of the fuel for heating power. It is very important for users of soft coal to bear this fact in mind, as the difference in the available heating value of the two fuels will run about 40 per cent.

TABLE "A."

Calorific Power, or Heating Values of Various Fuels. (Approximate only.)

	1 Volatile Matter Per Cent.	2 Fixed Carbon Per Cent.	3 Ash. Per Cent.	4 Theoretical Heating Power per lb. of coal. B. T. U.	5 Avail. Htg. Power when burned in best type house htg. Boiler: good comb'st'n B.T.U.
Anthracite average	4.00	85.00	9.50	13200	9000
Egg average	....	88.50	6.50	.....	....
Pea average	....	79.00	15.00	.....	....
Semi-Bituminous					
Pocohontas	21.00	74.39	3.50	15000	8500
New River	18.00	77.64	3.50	15200	8500
Bituminous—					
Caking	35.00	56.00	6.30	14000	7500
Non-Caking	33.00	56.00	6.30	13000	5300
Lignites—					
Iowa and Oregon	37.00	35.00	18.00	8500	....
Wyoming and Utah	39.00	43.00	7.00	10500	....
Coke—best quality	1.65	90.00	7.80	13500	9500

(The balance of 100 per cent is chiefly moisture and surphur.)

The lignites are found in Iowa, Wyoming, Oregon and Utah. Those of Iowa and Oregon have about the same theoretical heating power, which is about 8,500 B. T. U. per pound. Those of Wyoming and Utah will run about 10,500 B. T. U. per pound.

We have already called attention to the fact that the semi-bituminous coals, which are found in Pennsylvania, Maryland, Virginia and West Virginia, have the highest heating value per pound of any coals in the United States. To make this clearer we will give the heating value per pound of combustible, which, for anthracite coal is 14,000, for "Pocahontas" 15,700, and for "New River" 15,800 B. T. U. per pound. The heating power per pound of combustible of the semi-bituminous coals is very uniform, not varying more than 800 or 900 B. T. U. They are also very low in moisture, ash and sulphur, so that they are exceptionally valuable as steam coals, and more especially so for power boilers, where the fuel is put on the fire at frequent intervals and in small quantities.

The reason that anthracite coal does not yield as high a heating value as does the semi-bituminous, is because the latter has a higher percentage of hydrogen, which, as we all know, produces, under certain conditions, the highest temperature of combustion, being about 62,000 B. T. U.

In the bituminous coals, besides the difference between caking and non-caking coals, there is a great difference in the moisture contained in the various soft coals. Those of Illinois are said to contain more moisture than any other bituminous coals mined in the United States, and for this reason they have not as high a heating value as have the soft coals of Ohio, Indiana and Pennsylvania. For example, the moisture in Connellsville coal is 1.26 per cent., while that in Streetor, Ill., is given as 12.00 per cent. This is a remarkable difference, and where people are obliged to burn soft coal in their boilers they should be careful to procure the variety which gives in their heating apparatus the best results.

We come now to coke, and wish to call attention to the important fact that coke shows the highest available heating power of any fuel given in Table A. One reason for this is that a body of coke lying in the fire box of a boiler is only a little more than half the weight per cubic foot of anthracite coal, and for this reason does not pack closely, permitting the air to pass through it freely. The combustion is invariably better, and the resultant heating effect greater than can be obtained from anthracite coal.

With the exception of gas, there is no fuel available for domestic purposes that will yield as high a percentage of heating power and show a greater economy than will a good quality of coke. It is also a much cleaner fuel, for the reason that the percentage of ash is low, and being heavy per bulk does not fly about as does the light, feathery ash given off from anthracite coals. As a rule, a fire of anthracite coal will require a thorough cleaning at the end of ten or twelve hours, otherwise it will soon begin to lose its heating power for want of oxygen. Under such circumstances the fire becomes dull and dead and the coal decomposes without yielding anything like its quota of heat. Under like conditions a coke fire will be clean and bright, and it is just this characteristic of coke which makes it so valuable a fuel for house heating purposes.

It is true that very little is known in regard to burning of coke in the United States. In the countries of Europe, where the coal is of an inferior quality, they have been obliged to make coke of it and use it for heating their houses, and in this way they have become familiar with its use and have made special appliances for burning it.

The American Radiator Company, recognizing the fact that coke required an apparatus entirely different from the ordinary coal-burning boilers, made a series of experiments with the various kinds of coke, and have evolved a coke-burning boiler which has proved very successful. They have been selling large numbers of these boilers in Europe and are now introducing them into this country. In Fig. 146 is shown a complete

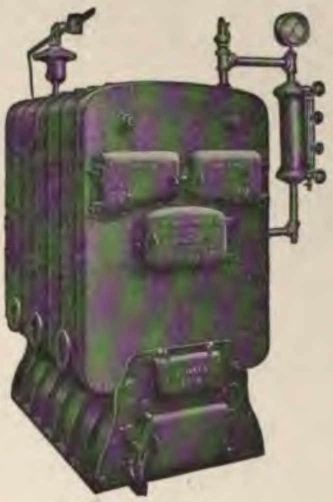


FIGURE 146

coke steam boiler. In Fig. 147 is shown the same boiler with the front taken away, which gives an interior view of the fire box and a portion of the heating surface.

It will be noticed that the sections are drawn in sharply at the grate line. This not only reduces the grate area and gives the proper amount of air for the combustion of the fuel, but it forms a bridge to support to fuel body so that the grates may be cleaned by passing a slice bar over them without in any way disturbing the fuel. This is a very valuable feature and can best be appreciated by those who have had one of these boilers in operation, giving them an opportunity for comparison with coal-burning boilers.

Fig. 148 is a rear view of the boiler, which shows the draft damper in the bottom of the rear base plate. It also shows the cross damper in the smoke hood, which may be attached to the same regulator chain that controls the supply of air, and the two working together automatically gives perfect control of the fuel combustion.

The fuel capacities of these coke boilers are very much greater than will be found in any other type of house-heating boiler. This is a necessity for the reason that coke weighs 28 pounds per cubic foot, while anthracite coal weighs from 50 to 55 pounds per cubic foot. With a good quality of coke and a properly designed steam or water heating job, fire can be maintained in these coke boilers from twelve to twenty-four hours, while under the same conditions a fire of anthracite coal would not last longer than from eight to fifteen hours.

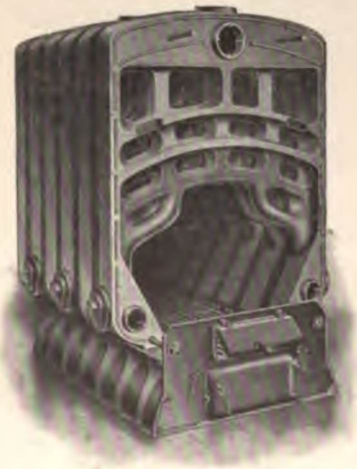


FIGURE 147

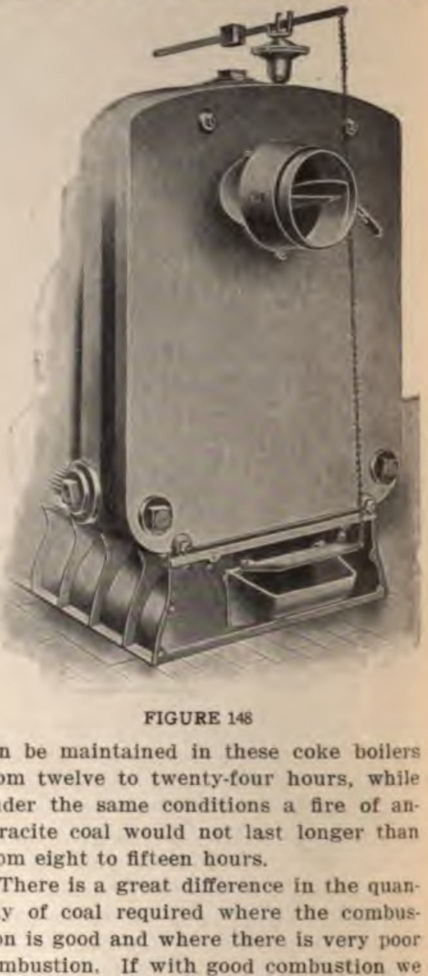


FIGURE 148

There is a great difference in the quantity of coal required where the combustion is good and where there is very poor combustion. If with good combustion we burn a fuel and utilize from each pound 9,500 heat units, we will, of course, require only half as much fuel as though we were burning fuel which yielded but 4,500 units per pound. To make this plain we will suppose that a given heating apparatus, burning fuel to the very best advantage and utilizing 9,500 heat units from each pound of fuel burned, requires 20 tons per season. Then if the same fuel be burned in the same apparatus and for some reason will yield but 9,000 heat units per pound of fuel, there will be required 21.10 tons per season. Table B, which follows, shows the heating power available from 9,500 heat units per pound down to 4,000 and the corresponding amount of fuel required for a given job, assuming that the first item requires 20 tons per season.

TABLE "B."

Heating Power Available B. T. U.	Tons per Season.
9500	20.00
9000	21.10
8500	22.40
8000	23.75
7500	25.40
7000	27.20
6500	29.20
6000	31.60
5500	34.60
5300	35.80
5000	38.00
4500	42.20
4000	47.50

This table shows how important is the selection of a boiler designed for a specific purpose so that the greatest possible power may be extracted from the fuel. The attempt to burn coke in a boiler designed for coal will be met with disappointment. Repeated experiments, carefully conducted, show that coke which will yield an available 9,500 B. T. U. when burned in a well designed coke boiler, will yield but 7,000 B. T. U. burned in a boiler designed for coal, requiring, as shown by Table B, 27.20 tons instead of 20; an additional expenditure for fuel of thirty-six dollars, and beside the fire would have to be replenished every five or six hours in the make-shift boiler instead of once in ten or fifteen hours in the boiler especially designed for coke.

In Table C, which follows, we assume a price per ton for the standard fuels for comparison; the prices will, of course, vary according to the locality and season:

TABLE "C."

Coke	20.00 tons at	$5.00	$100.00
Authracite coal.....	21.10 tons at	6.50	137.15
Semi-Bituminous	22.40 tons at	4.00	89.60
Bituminous Caking..	25.40 tons at	3.00	76.20
Bitum. Non-Caking...	35.80 tons at	3.00	107.40

The cheapest fuel in the table is the bituminous caking coal and it would, no doubt, be used more generally than it is but for the fact that so far no house-heating boiler has been constructed that will burn soft coal properly. In the large square boilers it can be burned to very good advantage, but when it is attempted to burn soft coal in small boilers with 19-inch or 21-inch fire pots, there is found great difficulty in maintaining a fire for any length of time, or in getting good combustion.

Soft coal requires in the first stages of combustion a large volume of air supplied to all parts of the fuel, and if this is not done there will be a great volume of smoke and the gases accumulating will frequently on coming in contact with a small quantity of air on the surface of the fuel, explode. This can all be prevented when boilers are so constructed as to give the proper amount of air to the fuel at the time when it is most needed, and that is while the fuel is distilling its gases. After that such an excess of air will dilute the gases and lower the efficiency of the boiler very rapidly, so that some device must be invented which will give to the soft coal fuel all the air it requires while distilling the gases, and then automatically shut off and supply only the quantity of air required for the proper combustion of the fixed carbon which is left.

CHAPTER XXXV.

PIPING CONNECTIONS FOR STEAM BOILERS—DRY AND WET RETURNS.

A SOURCE of considerable annoyance to users of steam boilers is the inability at times to maintain a steady water line in the gauge glass. In some cases the water races violently up and down the glass, and in others the water leaves the glass as soon as pressure shows on the steam gauge.

What makes the water leave the glass is a question to which many different answers are given. The theory most frequently heard is that the difference in pressure between the boiler and the return line causes the water to rise in the return pipe and lowers the body of water in the boiler. A moment's reflection, however, will show the fallacy of this reasoning, for a difference of one pound would cause the water in the return to rise only about two feet. If all the mains were flooded and the boiler refilled the water would again leave the glass with the rising pressure.

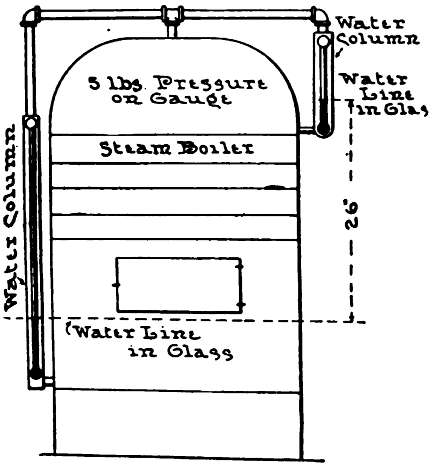


FIG. 149—SHOWING EFFECT OF DRAFT ON GAUGE GLASS

In a system of steam piping which is largely used in France and Germany, the pressure, of from one to five pounds, is all on the steam lines with no pressure on the returns, and as a consequence the water rises in the return until the column of water balances the pressure and yet there is no complaint of the water leaving the glass in the boiler.

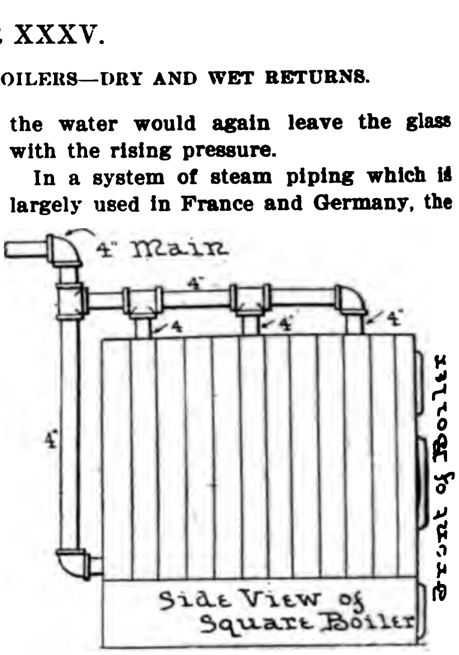


FIG. 150—STEAM BOILER CONNECTION

From the writer's observation the phenomenon is caused by the rapid movement of the water in the leg of the boiler, which sucks the water out of the glass and water column. The water does not go out of the boiler under such conditions, as has frequently been proven. To prove this a simple experiment was made with a boiler. One water column with a ten-inch glass was connected both top and bottom to the steam dome; another water column with a 30-inch glass was connected with the top to top of dome, and the bottom to bottom of fire pot.

When the gauge showed five pounds pressure the water in the 30-inch glass stood 26 inches below the water in the 10-inch glass—the latter showing 3 inches of water. (See Fig. 149.)

Nearly all the round boilers made today are trimmed with the lower end of the water column attached to the bottom of steam dome below the water line, and this method has proved to be much more satisfactory than the old way of connecting to bottom of water leg.

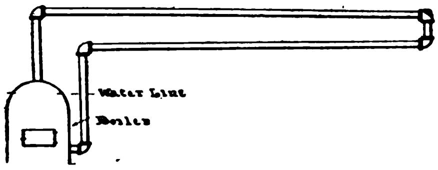


FIG. 151—ONE PIPE SYSTEM. DRY RETURN

The reason the water is not sucked out of the glass when the bottom connection is in the steam dome is because the water at that point is quiet compared with the upward movement of the water in the fire pot, where a thin body of it comes in contact with the glowing fuel. If any reader doubts this, let him take any round boiler whose water column is connected to top and bottom of steam dome and connect the lower end to bottom of fire pot.

In square or vertical sectional boilers the case is different for the reason that the steam dome is cut up into as many compartments as there are sections in the boiler and the difference between the volume of water in the dome and water leg is not so great as it is in round boilers.

Sometimes, under a very strong draft, water will be carried into the steam pipes with the outgoing steam and clinging to the sides of the pipe be forced into the radiators. This is always caused by the high velocity of the steam leaving the boiler and may be prevented by taking more, or larger, openings out of the dome, which will stop the water following the steam and will steady the water in the gauge glass.

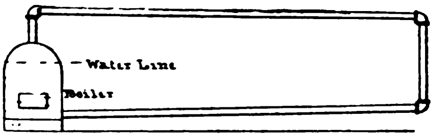


FIG. 152—SUBMERGED RETURN ABOVE BASEMENT FLOOR

It is a common practice to bush the tappings in the steam outlet to the size of the steam main, which is very bad practice. If the tapping is 4 inches and the steam main 3 inches, the riser should be 4 inches with a 4-inch by 3-inch ell to receive the 3-inch main. If the tappings are 3 inches, two 3-inch risers should be connected to the 3-inch main. (See Fig. 150.) The reason for this is that the more openings of large area there are out of the steam dome, irrespective of the size of the main, the lower will be the velocity of the steam as it leaves the boiler, and with a low initial velocity there is less liability of the water being carried out with the steam or of disturbing the water in the gauge glass.

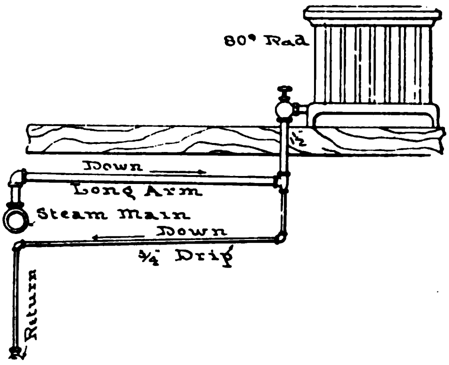


FIG. 153—SUBMERGED RETURN BELOW BASEMENT FLOOR

Suppose, for example, that with one 3-inch or one 4-inch riser from the steam dome the initial velocity of the steam is 40 feet per second, then by taking off another riser of the same size the velocity will drop to 20 feet per second.

It is also good practice to connect a "bleeder" or relief pipe to the steam main, as shown in Fig. 150.

The U. S. Government Commission, who tested a large number of power boilers at the Centennial Exposition at Philadelphia in 1876, reported that where they found any trouble from boilers priming the difficulty was obviated by taking more openings out of the steam dome, and the practice can be applied with equally good results to steam boilers of the house heating type.

To water heating boilers this does not apply, for the more rapidly the water leaves the boiler the better will be the circulation throughout the apparatus.

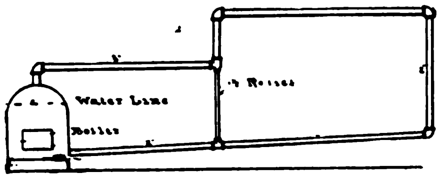


FIG. 154—ONE PIPE SYSTEM RELIEF IN MAIN STEAM LINE

Referring to the one-pipe system of steam heating, the question is sometimes raised, "Which is the better way to carry the return back to the boiler—dry, or submerged—that is, below the water line." Some claim that with a dry return the boiler will do better work than when the returns are submerged.

The writer's preference is for the submerged return where the boiler has direct, and therefore sensitive, heating surface. Where the return is hung above the water line, the water of condensation returns to the boiler about the temperature of the steam and where there is a sharp draft and direct heating surface, the water in the boiler becomes almost as hot at one point as another, and as a consequence the circulation is not so good and the boiler loses its efficiency, because the water does not so readily absorb the heat. With the submerged return, the water lying in the pipe cools before reaching the boiler which gives a steadying effect, and creates a better circulation of the water because of the difference in temperature.

Fig. 151 shows a boiler and piping with dry return. Fig. 152 shows the submerged return, above the floor, and Fig. 153 shows the same in a trench below the floor. One advantage of the submerged return is that it can be utilized to drip the pipes at intervals where there is a long run, as in Fig. 154 or a radiator with a long arm leading to it can be dripped into the return, as shown in Fig. 155.

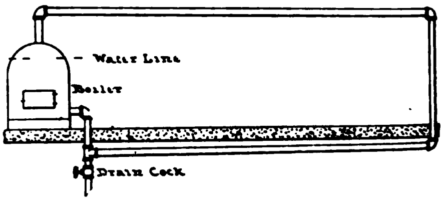


FIG. 155—SHOWING RELIEF FROM LONG ARM TO RADIATOR

CHAPTER XXXVI.

PIPE CONNECTIONS FOR STEAM AND WATER BOILERS.

WHERE two or more steam boilers are run on one set of piping, they are cross-connected, and sometimes the fitter has difficulty in keeping an equal water line in all the boilers. Fig. 40 shows two square boilers cross-connected, as they should be, to give the best results.

Two risers are taken out of the dome, both the same size as the pipe leading to the steam header. These pipes drop down into the header, from the under side of which an equalizing pipe is taken out and carried back to the return header. This helps to equalize the pressure between the two boilers in the event of one boiler being fired heavier than the other. It also acts as a bleeder for any water carried over by the outgoing steam in quick firing.

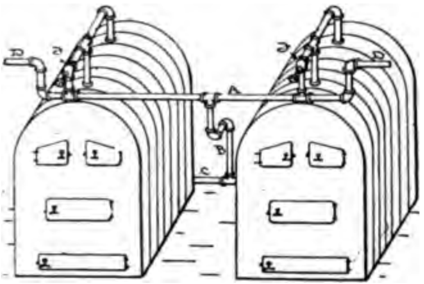


FIG.156 –FRONT VIEW OF STEAM BOILER CONNECTIONS. A, STEAM HEADER; B, EQUALIZING PIPE; C, RETURN HEADER; D, STEAM MAINS: E, RETURN MAINS: F, ANGLE VALVES

The object in placing the header in front of the battery is for convenience in handling the valves.

The return connection should be made as shown in the rear view, Fig. 157. A plan view is shown in Fig 158, with the proportionate sizes of the piping. Figs. 159 and 160 show clearly the details of the piping and connections.

It is a common occurrence to see on a battery of boilers check valves on the returns set against the boiler pressure to prevent the water going from one boiler to the other, but the checks in such cases do more harm than good, for if they prevent the water from going

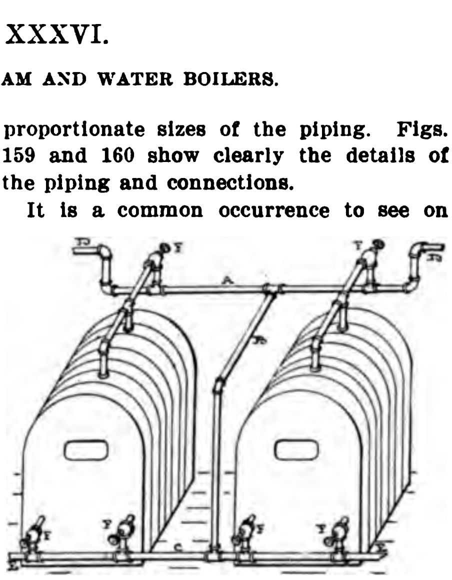


FIG. 157—A, STEAM HEADER: B, EQUALIZING PIPE; C, RETURN HEADER: D, STEAM MAINS; E, RETURN MAINS, F. ANGLE VALVES

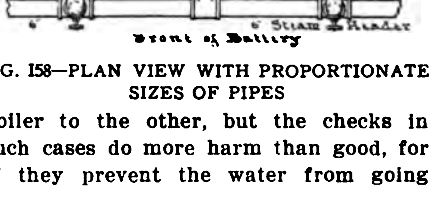


FIG. 158—PLAN VIEW WITH PROPORTIONATE SIZES OF PIPES

out of the boiler they will also prevent it coming in, and the boiler with no pressure against the check will get all the water of condensation until the column of water balances the pressure. If a free circulation is maintained between all the boilers in a battery by means of equalizing pipes, the water lever will be uniform, with very uneven firing.

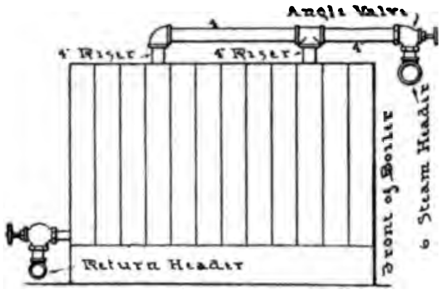


FIG. 159—PIPING AND CONNECTION

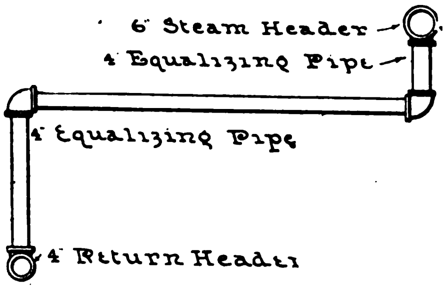


FIG. 160—PIPING AND CONNECTION

Where hot water boilers are connected in a battery, the equalizing pipe is unnecessary and the valves may also be dispensed with, though a job is more complete where each boiler can be cut out with valves in the event of a break.

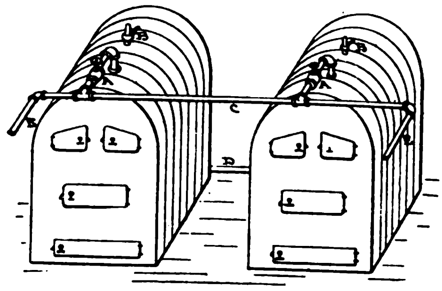


FIG. 161—FRONT VIEW HOT WATER BOILER CONNECTIONS. A, CUT-OFF VALVES: B, SAFETY LALVES: C, FLOW HEADER: D, RETURN HEADER: E, FLOW PIPES

Where there are no valves and only one boiler out of two is required, the water will move slowly through one boiler, just as though it were a part of the return main. Where only one of two boilers is run, it is mild weather and the drag of the additional water in the idle boiler is not noticeable.

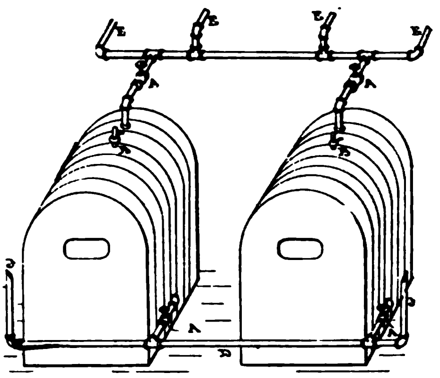


FIG.162—REAR VIEW, HOT WATER BOILER CONNECTIONS. A, CUT-OFF VALVES: B, SAFETY VALVES: C, FLOW HEADER: D, RETURN HEADER: E, FLOW PIPES: F. RETURN PIPES

If the boilers are valved, each boiler should have a good safety valve set about ten pounds above the static head; that is, if the water in the expansion tank is forty feet above the return of the boiler there will be at the lowest point of the boiler a pressure of 17.32 pounds per square inch. The safety valve should be set to open at 27 to 30 pounds.

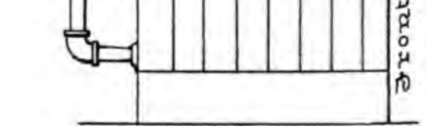


FIG. 163—HOT WATER BOILER CONNECTIOSN

If there are no safety valves on the

boilers and one boiler is shut off with the valves and remains idle for some time, there is always the danger that a fire may be started in it without first opening the valves, when the expansion of the water would quickly produce a pressure that would break the boiler. If equipped with a safety valve, under these conditions, the pressure would unseat the valve and throw out the excess of water, giving notice to the operator that he had not opened the main valve.

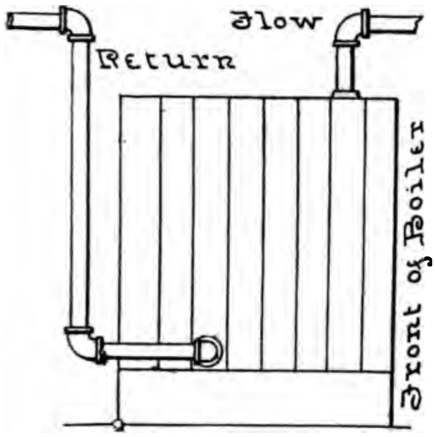


FIG. 164—HOT WATER BOILER CONNECTIONS

Fig. 161 is a front view of twin water boilers cross connected, and Fig. 162 is a rear view of the same.

The returns may be connected either to the back portion or one of the center sections—it does not matter which. It is generally supposed that the return water should enter at the end opposite the outlet, as in Fig. 163, but experiments along that line show that if there is any difference in results it cannot be measured with special instruments prepared for that purpose.

If the return enters the side of the boiler, as shown in Fig. 164, the water will enter the opposite side of the boiler through the bottom of the front and back sections, any movement of any portion of the water by expansion being instantly replaced by water of greater density.

CHAPTER XXXVII.

CAPACITIES OF TANK OR RANGE BOILER HEATERS—CONNECTIONS BETWEEN BOILER AND TANK.

IN Fig. No. 165 is shown a diagram for computing the capacities of small tank heaters, such as are used in residences and apartment buildings. In this diagram the horizontal lines represent tank capacities in gallons, each line being five gallons. Each vertical line represents one pound of coal, while the temperature is represented by the diagonal lines.

The smallest tank heater made by the manufacturers is a round heater having a grate 10 inches in diameter, this being as small as it is practical to make a coal-burning heater. Some years ago a small heater was put on the market with a 6-inch grate, the idea being to furnish a heater that would be large enough to heat 30 or 40 gallon tanks, which are commonly used in the kitchens of the average residences, but it was found impossible to keep a coal fire alive in these small boilers, for the reason that the walls of the fire-pot being surrounded by water presented a large area of cooling surface in comparison to the body of fuel, and the chilling effect was so great that combustion could not be maintained. After this lesson manufacturers have refused to make anything smaller than a 10-inch grate.

Looking over the catalogs of the various manufacturers, we find the tank heater with a 10-inch grate has a rated capacity for heating from 60 to 80 gallons of water. How many degrees the heater will add to this quantity of water, or how long it will take to raise it a given number of degrees, is not stated, but, as a rule, these small heaters are giving satisfaction, as they are usually attached to 30 or 40-gallon tanks and, except on wash days, have from four to six hours in which to heat the water in the tank.

By referring to the data at the bottom of the diagram, we find that the average hard coal capacity of a tank heater with a 10-inch grate is 25 pounds; deducting 5 pounds for re-kindling leaves 20 pounds available. If we run this boiler at slow combustion and burn the fuel at the rate of 2 pounds per hour, we can ascertain exactly how much work it will do attached to a 40-gallon tank, at that rate of combustion, by observing where the 2-pound vertical line intersects with the 40-gallon line. We find intersection is near the diagonal line marked "40 degrees." Therefore, the tank heater, under these conditions, will add 40 degrees per hour to 40 gallons of water, and will, of course, add 80 degrees in two hours, or 120 degrees in three hours, and as there is 20 pounds of coal available, and we are burning it at the rate of 2 pounds per hour, the fire will last for ten hours without attention.

If, however, we are obliged to run the boiler at its maximum capacity, we find by looking at the data that the maximum consumption of hard coal is 4½ pounds per hour and that, running at this rate, the fire will last but 4¾ hours. Then, if we look at the 4½-pound vertical coal line, we will find it intersects the 40-gallon line near the 100-degree line. Therefore, a tank heater burning coal at the rate of 4½ pounds per hour will add 100 degrees per hour to 40 gallons of water.

We find in the manufacturers' catalogs

that the 12-inch grate is rated to heat from 120 to 175 gallons of water. Suppose we take a 12-inch tank heater and attach it to a tank which contains 120 gallons of water. The maximum consumption of coal per hour in a 12-inch tank heater is 6½ pounds, and we find the 6½-pound vertical coal line intersects the horizontal 120-gallon line between the diagonal lines 40 and 60 degrees, which shows that a 12-inch tank heater, burning 6½ pounds of coal per hour, will add 45 degrees per hour to 120 gallons of water.

Suppose, again, we are asked to furnish a tank which will contain 120 gallons of water and attach to it a tank heater which will raise the temperature of the water from 40 degrees to 212 degrees, or 172 degrees in one hour. Turning to the diagram, we find the 172 diagonal line intersects with the 120-gallon line on the 24½-pound coal line, which shows that it requires a heater that will burn hard coal at the rate of 24½ pounds per hour to accomplish the required results. If we have a good draft and the best quality of coal, this may be accomplished by using a tank heater with a 21-inch grate, but it will be safer to use one with a 24-inch grate, if it is absolutely necessary to add 172 degrees every hour to 120 gallons of water.

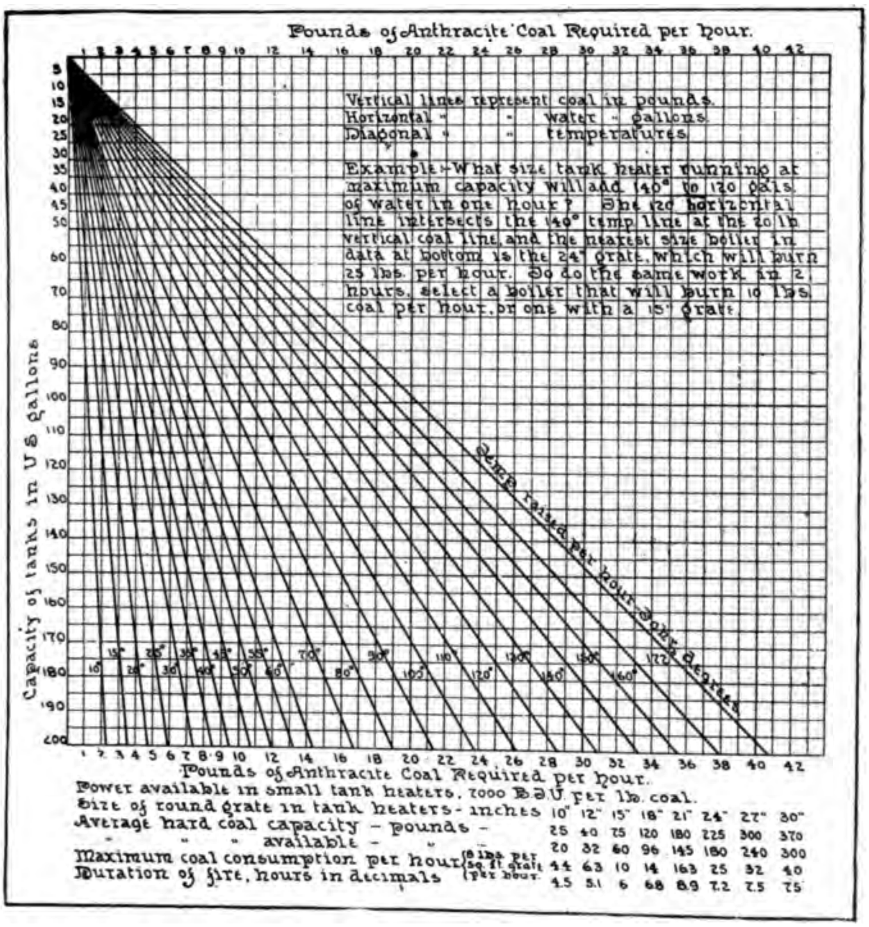


FIGURE 165—GRAPHICAL CHART OF TANK HEATER CAPACITIES

The rate of consumption of fuel is based on a square foot of grate burning from 8 to 8½ pounds per hour, and is not theoretical but has been proved by experiment.

It will also be noticed that we have assumed a low heating power available for each pound of coal burned, because experiments in this line show conclusively that in small tank heaters it is impossible to utilize more than 7,000 B. T. U. per pound, and unless the fuel is of a good quality, the yield of heat will run as low as 6,000 H. U. per pound. In the 21-inch and 24-inch, however, we may expect to develop a higher heating power from the fuel, but it will not exceed 7,500 B. T. U. per pound. One reason for this is that the water entering the boiler is comparatively cold, and while this is supposed to take up the heat very rapidly, it will also retard combustion, which is of the greatest importance.

It is the common belief that if a boiler is not doing the work expected of it, the proper remedy is to add more heating surface without increasing the grate or fuel space. This idea, however, is all wrong. There might possibly be a little more of the heating power of the coal utilized in the additional surface, but it would be more likely to cause a checking of the draft which would cut off the proper supply of air to the fuel and result in a decrease of heating power rather than in an increase. Almost any practical man has had this experience some time or other in his practice.

When a heating contractor once gets hold of the idea that it is the power in the burning fuel that is doing the work, and that there is a limit to the possibilities of a pound of fuel, he will then make fewer mistakes in the selection of boilers for a specific purpose.

The method of arriving at the quantity of coal required to add a given temperature to a given quantity of water is as follows: First, decide the heating power in B. T. U. which the boiler will utilize from each pound of coal burned. This will run from 7,000 for the smallest tank heaters to 8,500 for large heaters suitable for swimming pools. Then multiply the gallons of water to be heated by 8.33, or 8 1-3 pounds, which gives the water in pounds, and each degree Fahrenheit added to one pound of water is equivalent to one British Thermal Unit (usually designated B. T. U.), or Heat Unit (H. U.). We then multiply the pounds of water by the degrees Fahrenheit which the temperature is to be raised, and the result is the B. T. U. required per hour. This we divide by the fuel power available, which shows the pounds of coal required for one hour. If four hours is allowed in which to do the work, we divide the hourly requirement by four, which shows the coal required per hour for four hours, and dividing this by 8, the number of pounds of coal which it is safe to figure for each square foot of grate, we find the proper size of boiler.

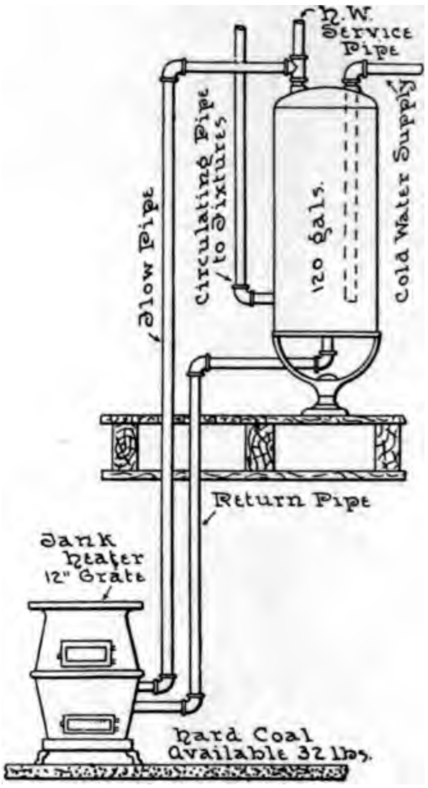


FIG. 166—METHOD OF CONNECTING UPRIGHT TANK TO THE HEATER

Example: What size boiler will be required to raise the temperature of the water contained in a 200 gallon tank from 40 degrees to 200 degrees, or a 160 degrees rise in four hours?

Multiply 200 by 8.33 and the product by 160, which gives 258,560 B. T. U. Divide this by 7,000, the heating power available in one pound of coal, and we have in round numbers 37 pounds coal required to do the work. Dividing the coal by four hours gives 9.2 pounds, which we must burn per hour for four hours to do the work required. Dividing this by 8, the consumption of coal per square foot of grate per hour, we find there will be required 1.15 square feet of grate, and we therefore select, as the nearest size a boiler with a round grate 15 inches in diameter. If the water must be raised 160 degrees in one hour, we must select a boiler that will burn 37 pounds of coal per hour, which will require a round grate 28 ins. in diameter.

In regard to the method of connecting the boiler to upright tanks. We find different men have different views on the subject. We show in Sketch No. 166 a method of connecting an upright tank to the heater which is very popular. It is said that by connecting the flow pipe to the top of the tank that where the water is cold and warm water is required in a hurry it can be heated more quickly with this connection than by connecting the flow to the tank at a lower point.

Where there is a circulating pipe to the fixtures, it is considered good practice to bring it back and connect it into the tapping of the tank that is usually used for the flow pipe when connected to ranges, as shown in the accompanying sketch.

CHAPTER XXXVIII.

HEATING SWIMMING POOLS BY STEAM OR WATER CIRCULATION.

RECENT experiments, conforming to working conditions, show that one square foot of pipe immersed in water will condense 0.155 pounds of steam per hour for each degree of difference between the temperature of the steam and the mean temperature of the water. This is equal to 150 B. T. U. per square foot per hour per degree of difference.

In chart B the horizontal lines represent water in U. S. gallons; the vertical lines represent hard coal in pounds at the bottom of the chart and the corresponding steam generated in pounds at the top of the chart. The diagonal lines represent the temperature increase or the number of Fahrenheit degrees which are to be added to the water in a given time.

In chart A the horizontal lines represent the mean or average temperature of the water in the tank which is to be heated, that is, if the water is to enter the tank at 50 degrees and the temperature of it is to be raised to 150 degrees, we obtain the mean temperature by adding 50 to 150 and dividing the sum by 2, which gives a mean temperature of 100 degrees. The vertical lines show the amount of water that one square foot of pipe will condense per hour when immersed in water of varying mean temperatures.

For example: If the mean temperature of the water in the tank is 100 degrees, we follow the horizontal line marked "100" to the intersecting line, and following the vertical line at the intersection, find that one square foot of pipe immersed in water of 100 degrees mean temperature will condense 15.5 pounds of steam per hour.

The following examples will show how the two charts can best be made use of:

Specification 1: A swimming pool containing 180,000 gallons of water receives the water supply at 40 degrees temperature, which must be raised to 80 degrees every 24 hours. The water will be warmed by circulating through water-heating boilers. Hard coal will be used. What size boilers are required and what will be the coal consumption for 24 hours.?

As the water must be warmed from 40 to 80 degrees we must add 40 degrees to this body of water every 24 hours. Turning to chart B we find that 1,000 gallons intersects the 40 degree temperature line at 40 pounds of coal. Then if 1,000 gallons requires 40 pounds, 100,000 gallons will require 100 times as much, or 4,000 pounds. In the same manner we find that 800 gallons will require 32 pounds and that 80,000 gallons will require 100 times 32, or 3,200 pounds, making a total of 7,200 pounds of coal required to add 40 degrees to 180,000 gallons of water. As we have 24 hours in which to do this work, we divide 7,200 by 24, which shows that we must burn 300 pounds of coal per hour.

With active combustion a well-constructed hot water heater will burn anthracite coal economically at the rate of 8 pounds per square foot of grate per hour. Divide 300 by 8 and we get 37.5 square feet of grate required in the boilers. If we select a boiler with grates 48 inches wide, the fire box would be nearly 9½ feet long, which would make it somewhat inconvenient for firing. It would, therefore, be better to select two boilers, each boiler to have half the required amount of grate surface.

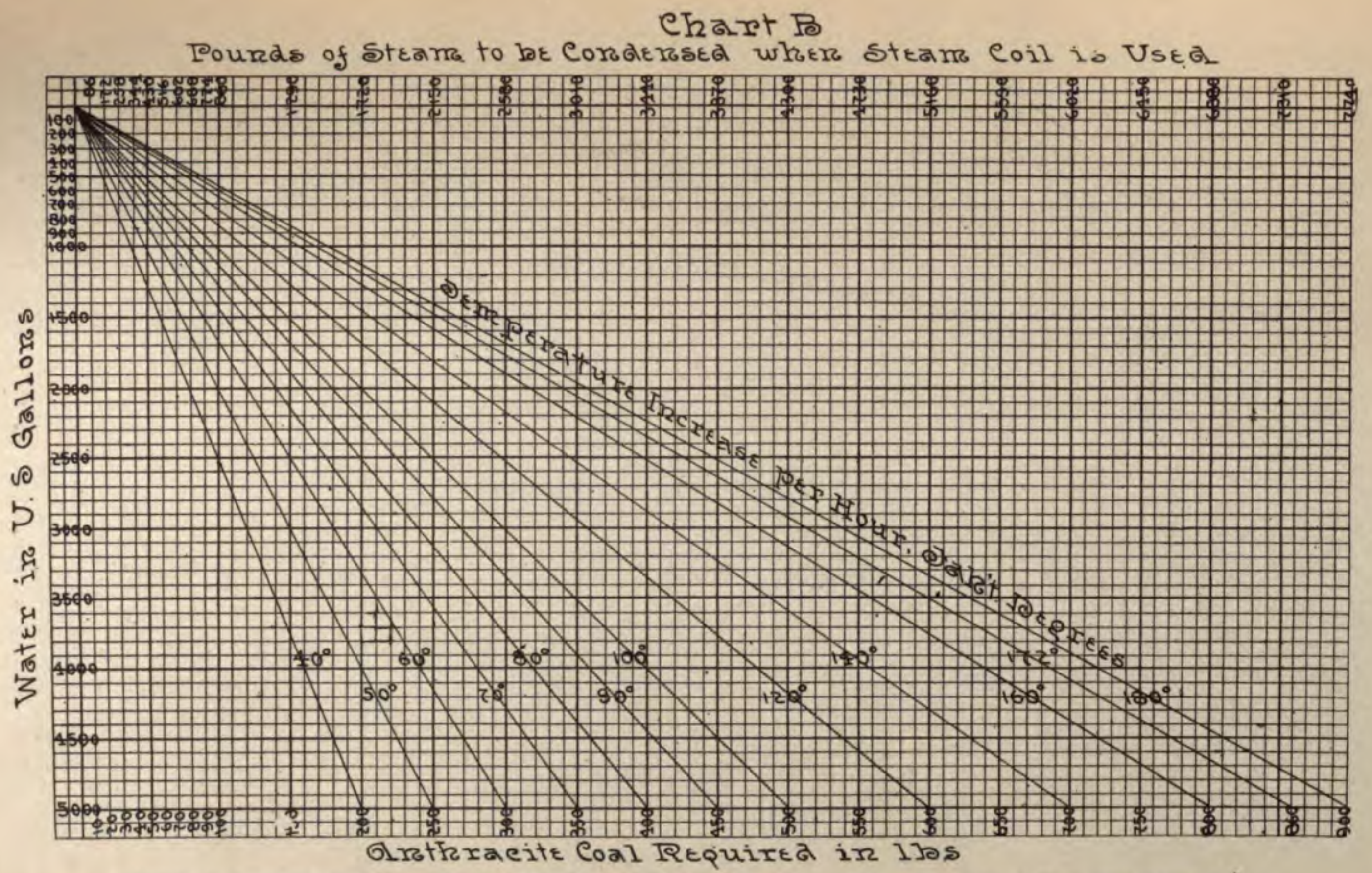


FIGURE 167—GRAPHIC CHART FOR FINDING THE BOILER POWER REQUIRED TO HEAT A PROPOSED SWIMMING POOL

If this body of water is to be heated by steam coils with steam at 10 pounds pressure, we find the mean temperature of the water is $80 + 40 \div 2 = 60$ degrees. The temperature of the steam at 10 pounds pressure will be 240 degrees and the temperature difference 180 degrees. Turning to chart A, we find the horizontal line marked "180" intersects the vertical line marked "27.87," that is, one square foot of pipe coil submerged in water where the temperature difference is 180 degrees, will condense 27.87 pounds per hour. As we are burning 300 pounds of coal per hour, which will evaporate 2,580 pounds of steam, as shown by chart B, we divide 2,580 by 27.87, which gives 93 square feet of pipe coil required in the tank. This, of course, supposes that the water surrounding the coil will maintain the temperature difference of 180 degrees, but as more than half of the work would be done while the water was quiet, the water in the immediate vicinity of the pipe would be at a much higher temperature and the condensing power of the pipe would, therefore, be reduced.

Then, again, a pipe coil immersed in water will gradually lose its efficiency or condensing power from corrosion or vegetable matter collected from the water. The corrosion can be prevented by using brass pipe, but nothing will prevent the vegetable mold from covering the pipes and unless they are frequently cleaned their condensing capacity will fall off very rapidly.

Considering these conditions and knowing something of the quality of the water to be used, there should be added to the quantity of pipe obtained by this rule from 50 to 100 per cent. In such cases it is well to have the pipe arranged in two distinct coils, so that while the pipe is new and effective one coil may be shut off when not required.

Specification 2′ A storage tank containing 300 gallons of water is to be heated by steam at 100 pounds pressure. The temperature of the water in the tank must be raised from 60 to 180 degrees every half hour. How much steam coil must we place in the tank to obtain these results?

As 120 degrees must be added to the temperature of the water every 30 minutes, we turn to chart B and find that 300 gallons of water will require 35 pounds of coal to raise its temperature 120 degrees and 35 pounds of coal will evaporate 300 pounds of water into steam which the pipe coil must condense.

In this case the mean temperature of the water is $60 + 80 \div 2 = 120$ degrees. The temperature of the steam is 240 degrees, making a temperature difference of 120 degrees.

We now turn to chart A and find the horizontal line marked "120" intersects the vertical line marked "18.6," the pounds of steam condensed by 1 square foot of pipe in one hour; as there are 300 pounds of steam to be condensed we divide 300 by 18.6, which gives 16 square feet of pipe coil which would be required to heat the water in one hour, but as the water must be heated in 30 minutes, we will require double the quantity of pipe, or 32 square feet.

Specification 3: 1,000 gallons of water in a storage tank is to be heated by circulating the water through a boiler burning a low grade of soft coal. The temperature of the feed water is 40 degrees Fahrenheit, to which must be added 120 degrees and the work must be done in 2 hours. How much coal must be burned per hour and what size boiler will be required?

Turning to chart B we find the horizontal line marked "1,000" gallons intersects the diagonal temperature line of 120 degrees near the vertical line representing 120 pounds of coal. As we have two hours in which to do the work, we will burn 60 pounds of hard coal per hour. To this must be added 25 per cent. for the equivalent weight in soft coal. This makes 75 pounds of soft coal which must be burned per hour. As we can depend on 1 square foot of grate burning 8 pounds of coal per hour in a free burning boiler, there will be required a boiler containing approximately 9.5 square feet of grate.

In selecting a boiler for burning soft coal, the best results can always be obtained from those having large flues and

60 per cent. or more of direct heating surface, which comes in contact with the fire and prevents accumulations of soot. Do not select boilers for soft coal purposes with indirect drafts or with long fire travel, or with a large number of small gas passages or flues, but rather select a boiler with a large fire box, so that there will be plenty of space for the combustion of the gases, and with a small number of large gas passages.

Specification 4: If the water in this 1,000-gallon tank is to be heated by steam and the steam is to be generated in a boiler burning soft coal, the same amount of coal will be required per hour, viz.: 75 pounds. To get the equivalent of hard coal we deduct 20 per cent. and this brings us back to 60 pounds of hard coal. We now turn to chart B and find that 60 pounds of hard coal will evaporate 516 pounds of water into steam, which must be condensed by the pipe coil placed in the tank. The mean temperature of the water is 100 degrees and the temperature of the steam we will place at 215 degrees, making a temperature difference between the steam and the water of 115 degrees. Turning to chart A we find the horizontal line 115 intersects at the vertical line marked "17.85." 516 divided by 17.85 is 29, which is the number of square feet of pipe coil required in the 1,000-gallon tank to raise the temperature of

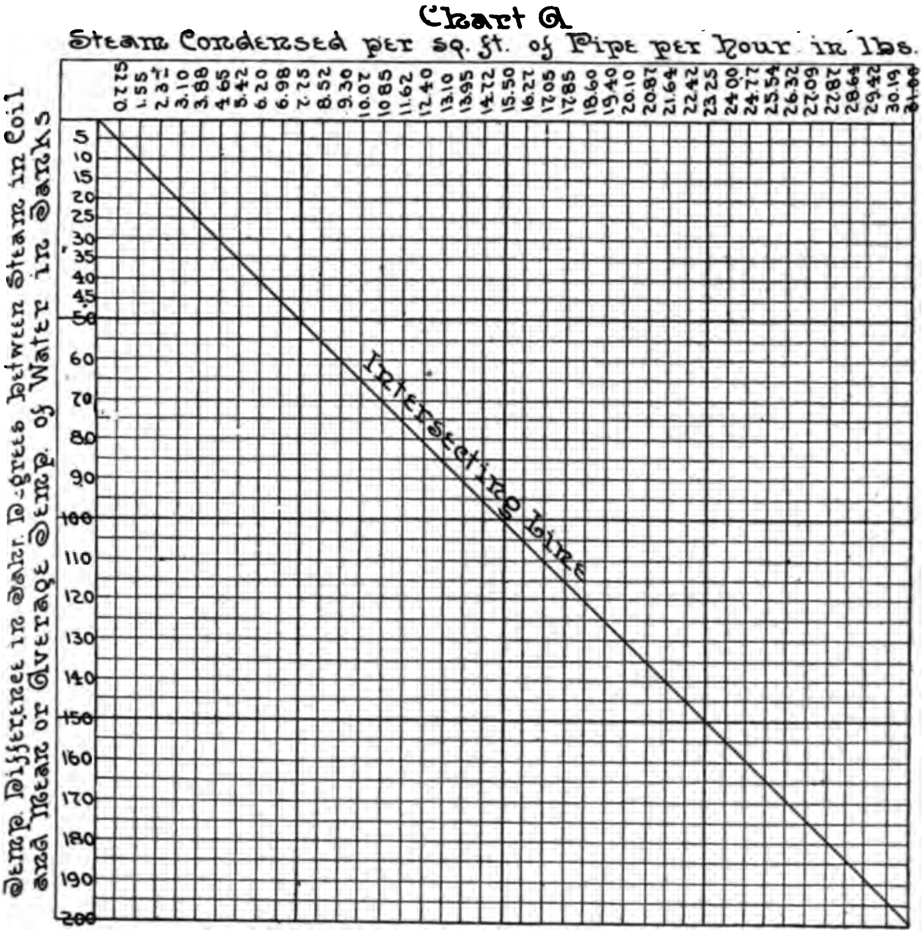


FIG. 168—GRAPHIC CHART FOR FINDING EXACT QUANTITY OF STEAM FOR HEATING WATER IN TANKS

the water from 40 to 160 degrees in two hours. This is a simple system.

If the work is to be done in one hour double the quantity of pipe will be required and double the grate area. The quantity of coal required to do the work will be the same, but double the quantity will have to be burned per hour, that is, it will require 120 pounds of hard coal or 150 pounds of low-grade soft coal, to yield the heat necessary to impart the increased temperature required to the water, so if the work is done in one hour we must burn 120 pounds of hard coal, or 150 pounds of soft coal, but if the work is done in two hours we burn half these amounts each hour. If a superior quality of soft coal is used add 10 per cent. to hard coal requirements. If semi-bituminous, such as Pocohontas or New River, coal be used, it will evaporate just as much water as will the very best hard coal.

On page 167 will be found a chart showing the requirements for heating small bodies of water with small tank heaters and by comparing that chart with the present chart B it will be noticed that a proportionately larger quantity of coal is required when burned in small tank heaters. This is because the coal does not yield as high a percentage of its latent heat as when burned in large boilers, and the reason for this is that the ratio of cooling surface (against which the coal lies) to fuel increases as the diameter of the fire pot decreases.

We very frequently hear complaints from steam fitters and plumbers that the heater or boiler which they have attached to a water tank will not do the work required and they immediately call on the manufacturer of the heater for redress. In some cases it is thought that the boiler has not enough heating surface; in others that the smoke pipe nozzle is not large enough; in others that the pipe leading from the boiler is not large enough. In fact, every possible reason and excuse is given but the right one, and that is, that the heater cannot burn enough coal per hour to furnish the energy required for the work in hand. By the use of the two charts accompanying this article, combined with the small tank heater chart shown a few weeks ago, the results looked for can be obtained without any guessing.

CHAPTER XXXIX.

HEATING SWIMMING POOLS BY STEAM COILS.

THERE are three methods by which large bodies of water, such as swimming pools, may be heated. First, the water may be circulated directly through a heater. Second, by steam filled coils submerged in the water. Third, by blowing steam directly into the water or mixing the steam and feed water before it enters the pool.

The first method, of passing the water directly through a heater is preferable where special boilers have to be provided for the purpose, but in many cases the building is equipped with power boilers and it is desirable to use the exhaust steam for heating the water. Where these conditions exist it is better to use pipe coils in the pool and run the steam through them.

The third method, of mixing the exhaust steam directly with the water, is open to the objection that oil from the engine is liable to be carried along with the steam and there is apt to be more or less noise in connection with this method.

As regards coal consumption it does not matter which method is used. There will be a given quantity of heat required which will be furnished by the fuel and it is hard to see where any one system would have any advantage in fuel economy.

If steam coils are used to heat a swimming pool they should be placed at the sides, which may be recessed to receive them, as in sketch Fig. 169. These pipes should be proportioned in size to the quantity of steam to be passed per hour. It is useless to expect a coil to condense any more steam than the pipe feeding it will carry. The following table gives the size of pipe that is safe to use for the different rates of condensation in the coils with low steam pressure:

Size of steam pipes to feed condensing coils.

Steam Condensed by the Coils per hour. in pounds.	If 1 pipe is used. Inches.	If 2 pipes are used. Inches
100	1¼	
200	1½	
300	2	0
400	2½	2
500	2½	2
600	3	2½
700	3	2½
800	3½	2½
900	3½	2½
1000	4	3
1500	4½	3
2000	5	3½

As the steam condenses so rapidly in the coils when immersed in the water it is not necessary that their combined area should be equal to that of the feed pipe, but it is good practice to use a 2-inch or 2½-inch pipe when the coils are of unusual length, as in swimming pools.

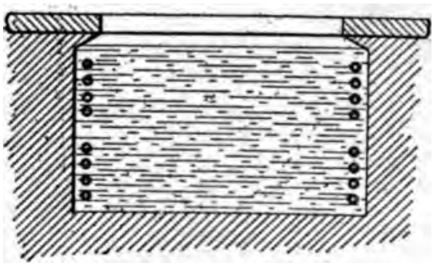


FIG. 169—END ELEVATION OF SWIMMING POOL, SHOWING POSITION OF STEAM COIL

It is also better to use branch tees in these long coils, as the friction is too great in a return bend coil, see sketch, Fig. 170, in which the steam travels the length of the tank twice, or 200 feet in a pool 100 feet long, while with return bend coils, the steam travel would be 800 feet. This arrangement, Fig. 59, requires coils on both sides of the pool and two steam supply pipes, which is better than to have one supply and carry the steam from that supply around both sides and one end. Another reason why short runs are to be preferred is because in long runs of pipe a larger portion of it is issued as a drain for the condensation, and becomes thereby inefficient.

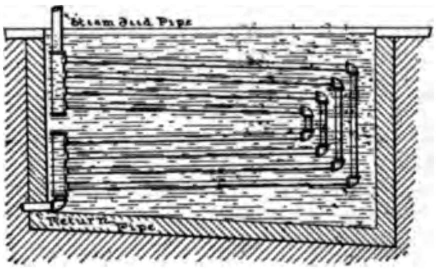


FIG. 170—STEAM HEATING COIL IN SWIMMING POOL

If it is desired to heat the water by circulating it directly through a heater, the latter should be located in a pit or sub-cellar at the deep end of the tank and the flow pipes extended to the further and, as in sketch, Fig. 171. There should be two flow and two return pipes, as shown in the end view of pool, Fig. 172.

We give the following examples of problems in heating water which the diagrams 167 and 168 make easy of solution.

Specification:

A swimming pool containing 250,000 U. S. gallons of water is to be raised in temperature from 40 to 80 degrees every ten hours. The steam will be furnished from the exhaust, supplemented with live steam when necessary. How many pounds of steam and coal will be required per hour and how many square feet of coil will be required for the pool?

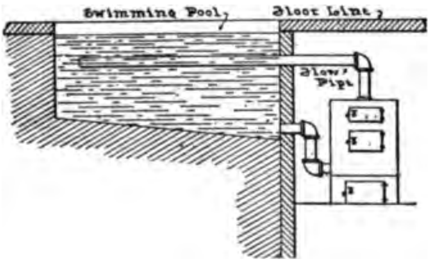


FIG. 171 SHOWING METHOD OF HEATING POOL WITH WATER HEATER

Referring to diagram, Fig. 167, we find that 5,000 gallons require 200 pounds of coal and 1,720 pounds steam to raise the temperature 40 degrees in one hour. To the work in ten hours requires 1-10 the quantity or 20 pounds of coal, and 172 pounds of steam, and as 250,000 is 50 times greater than 5,000, we require of coal per hour 20 × 50 = 1,000 pounds, and of steam 172 × 50 = 8,600 pounds per hour.

The temperature of the steam is 212 deg. F.; mean temp. of water, 60 deg.; temperature difference, 152 deg.

Chart A, Fig. 168, page 173, shows that one square foot of pipe at a temperature difference of 152 deg. will condense 23.5 pounds per hour and 8,600 divided by 23.5 is 360 square feet of pipe coil required.

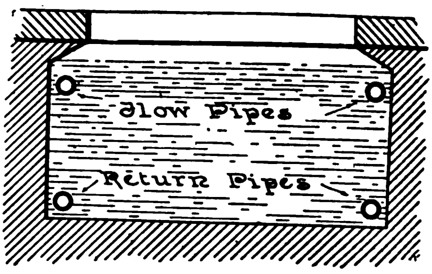


FIG. 172—POSITION OF PIPES FOR CIRCULATING WATER THROUGH A HEATER.

As 30 pounds of water evaporated per hour equals one horse power, we have

$$\frac{8,600}{30} = 286$$

horse power required in boilers.

Another example:

Eight hundred gallons of water are to be raised from 40 to 212 degrees per hour and the heat is to be transmitted by circulating the water through a heater. What size water heater is required?

Referring to Fig. 167, page 171 (we find that 140 pounds of hard coal will be required per hour, and we must select a boiler which will burn that quantity per hour. With a good draft, a well-proportioned boiler will burn 8 pounds of hard coal per square foot of grate per hour and

$$\frac{140}{8} = 17.5$$

square feet of grate and from 200 to 250 square feet of heating surface.

If 75 to 80 per cent. of the heating surface is direct, 200 square feet will be ample, for it must be remembered that if the boiler has a large amount of heating surface, it will be difficult to burn the coal at a rate of 8 pounds per square foot of grate per hour, because of the impeded draft, and that with the direct draft boiler we get, as a rule, better combustion and a greater yield of heat from the fuel.

When radiation is used to dry out the plaster in a new house in winter, it frequently happens that the boiler cannot make steam as fast as it condenses in the radiation, and in such cases the boiler is said to be too small or "no good," when, as a matter of fact, owing to the air being saturated with water, the radiation is condensing the steam at about double the normal rate. This has frequently been proved in practice. When a boiler which seemed to be too small has been allowed to remain until the rooms were thoroughly dry, no further complaint of insufficient boiler power have been heard.

CHAPTER XL.

HEATING WATER FOR GREENHOUSES FROM STEAM BOILERS.

WE have had a number of inquiries of late regarding the heating of residences and greenhouses by water, heated by steam. In some cases the parties have a low pressure steam heating apparatus in their houses and propose to heat the greenhouse by taking steam from the boiler to heat the water for that purpose. In other cases they desire to take steam from a power plant and heat water in a tank and from that circulate the water through the house. Both of these methods are feasible if the conditions are right.

When it is desired to use steam from a low pressure boiler already installed for some other purpose, the first thing is to find how much steam the new addition will require, and, if the boiler is capable of supplying that in addition to its regular work.

A great deal has been written by different authorities in regard to the amount of heat given off by a steam pipe immersed in water and scarcely any two of the authorities agree. Possibly one reason is that these experiments were made on a small scale and when put into practice there has not been sufficient allowance made for loss of heat and changed conditions. In order to get a line on the transmission of heat from a steam pipe immersed in water, the writer has recently made a series of experiments, following as closely as possible practical methods. The result of these experiments shows that one square foot of pipe, filled with steam and immersed in water, will condense 0.155 pound per hour for one degree Fahrenheit difference of temperature between the steam in the pipe and the water surrounding it.

In taking the temperature of the water, we always take the mean temperature. For example: If the initial temperature of the water is 60 degrees and the terminal temperature 100 degrees, the mean temperature is obtained by adding 100 to 60 and dividing by two, showing in this a case a mean temperature of 80 degrees. If the steam in the pipe is at 220 degrees, the temperature difference will be 140 degrees, and 140 multiplied by 0.155 gives 21.7 pounds of steam condensed in one hour by one square foot of pipe. If the temperature difference were only 70 degrees, then we would have 70 multiplied by 0.155, which gives 10.8 pounds condensed by one square foot in one hour. This is just half the amount the pipe will condense when the temperature difference is 140 degrees, and shows the importance of knowing the conditions befor attempting to install any such work.

While it is impossible to tell exactly the loss of heat in passing through a given amount of radiation, the loss can be approximated pretty closely. For example: In the ordinary residence work, with the water circulating through 1,000 feet of radiation, the water will return to the boiler at a loss in temperature of about 20 degrees. In greenhouse work it is not safe to figure less than 40 degrees loss.

To make this matter clear to our readers, we show in Fig. 173 an illustration of a hot water heating apparatus in a greenhouse being warmed by steam from a low pressure boiler. In this case there are 600 feet of water radiation in the greenhouse and in the residence there are 800 square feet of steam radiation attached to the boiler. The 600 feet of radiation in the greenhouse will lose 400

B. T. U. per square foot per hour, a total of 240,000 B. T. U. per hour. This divided by 960, which is the quantity of heat liberated by one pound of condensed steam, gives 250 pounds of steam which must be condensed per hour to liberate the necessary amount of heat to make up this loss. The temperature of steam in the pipe we take at 220 degrees, the outgoing water at 180 degrees and the return water at 140 degrees. This gives us a mean temperature in the water of 160 degrees, and 220 — 160 = 60 degrees temperature difference between the steam pipe and the water surrounding it. This 60 degrees multiplied by 0.155 gives us 9.3 pounds of steam condensed in one hour by one square foot of pipe, and as we must condense 250 pounds, we divide 250 by 9.3 and find the tank requires 27 square feet, or 62 linear feet of 1¼-inch pipe. This can be put in a tank 8 feet long and 30 inches diameter, which will contain 300 gallons.

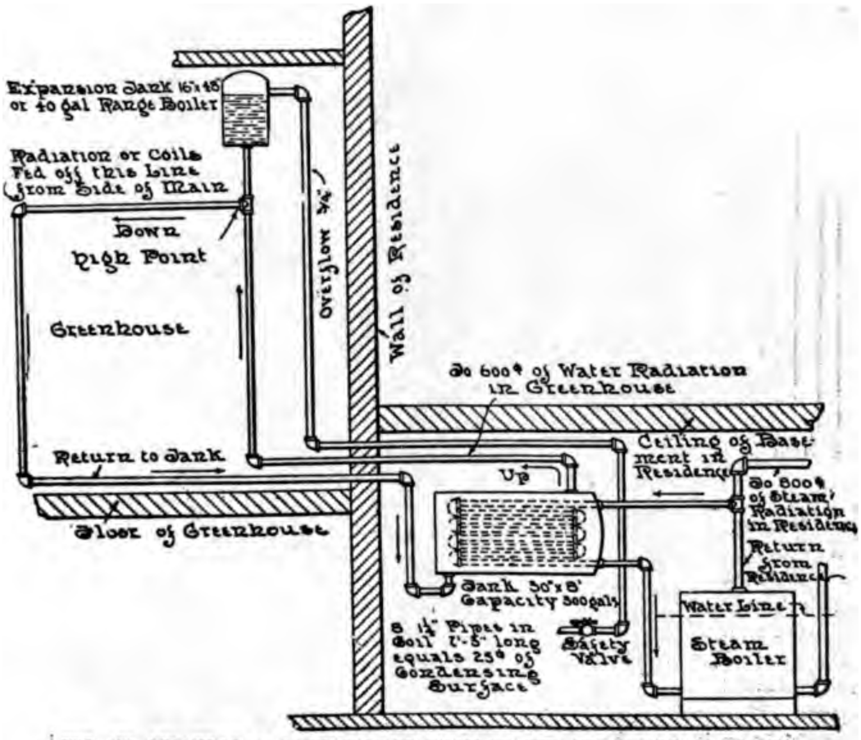

Expansion Tank 16"x48" or 40 gal Range Boiler
Radiation or Coils Fed off this Line from Side of Main
Down
High Point
Greenhouse
Overflow ¾"
Wall of Residence
Return to Tank
Floor of Greenhouse
To 600# of Water Radiation in Greenhouse
Ceiling of Basement in Residence
Up
To 800# of Steam Radiation in Residence
Return from Residence
Tank 30"x8' Capacity 300 gals
8 1¼" Pipes in Coil 7'-8" long equals 25# of Condensing Surface
Safety Valve
Water Line
Steam Boiler

FIG. 173—HEATING A GREENHOUSE WITH WATER FROM STEAM BOILER

The capacity of the tank is not essential. It must, however, be large enough to contain the pipe coil in a horizontal position and the bottom of the coil must be above the water line of the steam boiler.

In some localities they use a much larger tank than is suggested here in order to have a reservoir to furnish hot water when the fire is low. There may be some little gain in this, but very little as the water will very quickly cool down when there was no steam entering the pipe, and we believe that nothing is gained by making a tank larger than is necessary to hold the proper amount of pipe to heat the water. (Put the extra money into a larger boiler that will furnish steam for 10 or 12 hours without attention.)

To furnish this much steam we assume that each pound of coal burned will evaporate eight pounds of water, and 250 divided by 8 gives 31 pounds of coal required per hour. Assuming that the boiler is run at a rate of combustion that will burn 6 pounds of coal per hour per square foot of grate, we find there will be required a boiler with 5 square feet of grate.

As there are 800 square feet of steam radiation in the house where the air is 70 degrees, we figure that each square foot will condense 0.3 pound of steam per hour, or 240 pounds of steam. Dividing this by 8 gives 30 pounds of coal required; 30 divided by 6 gives 5 square feet of grate; so there would be required to furnish steam for 800 feet of steam radiation in the house and 600 feet of water in the greenhouse a boiler with 10 square feet of grate. This would mean a square boiler with a grate 36 inches wide and 40 inches deep, or a 6-section 36-inch square boiler.

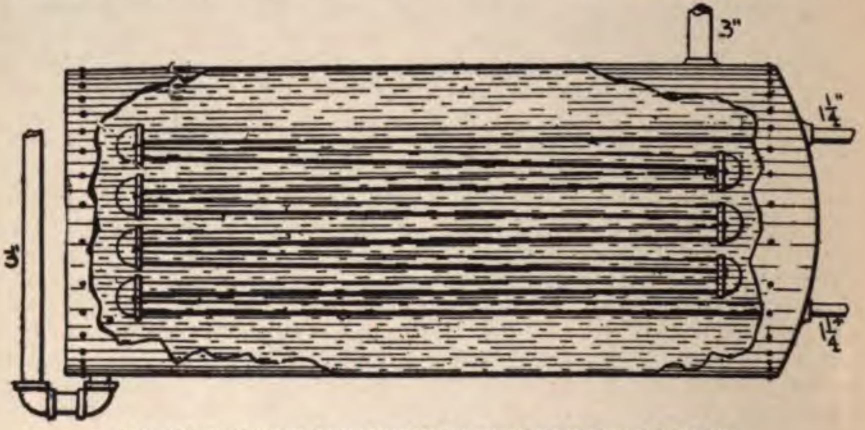


FIG. 174—SHOWING ARRANGEMENT OF STEAM COIL IN TANK

If it is desired to heat a residence with steam from a high pressure boiler in the neighborhood, the steam should be reduced to about 10 pounds before it enters the house. The condensed water from the coil would have to be taken back to the boiler room and trapped into receiving tank and thence pumped back into the boiler. In all other respects the apparatus would be the same as is shown in sketch 106. In sketch 174 tank is shown in detail.

In figuring for 10 pounds of steam in the coil, we will call the temperature of the coil 239. We will call the water going out of the tank 180 and returning 160, giving us a mean temperature of 170 degrees, and 239 — 170 = 69 degrees temperature difference between the steam coil and water surrounding it, and 69 multiplied by 0.155 is equal to 10.7 pounds of steam condensed per square foot of pipe coil per hour. Then if there are, say, 1,200 feet of radiation in the building, we must condense 360 pounds of steam per hour to furnish the heat lost in warming the rooms, and 360 divided by 10.7 gives us 33.5 square feet of pipe coil required in the tank.

CHAPTER XLI.

REDUCED PIPE SIZES FOR STEAM HEATING APPARATUS—CORRECT AND INCORRECT METHOD OF PIPING CONNECTIONS TO STEAM DOME.

IN this article we show basement plans of a building 80 feet long and 50 feet wide. In Fig. 175 the piping is shown in two circuits. One 2½-inch circuit leaves the boiler and takes in one-half of the building, the other half being covered by a 2-inch circuit. The 2½-inch line is 112 feet in length from where it leaves the boiler until it drops into the submerged return at the opposite side of the building. There is attached to this 2½-inch main 710 square feet of radiation, divided into thirteen radiators. The 2-inch line is 120 feet in length from where it leaves the boiler until it drops into the wet return, and carries 560 square feet of radiation divided into ten radiators.

In ordinary practice where we show a 2½-inch circuit, 3½-inch or 4-inch would be used, and where we show a 2-inch circuit, a 3-inch would be used.

The object of this article is to show how pipe sizes may be safely reduced, thereby reducing materially the cost of installation in low pressure steam heating apparatus.

We will assume that an apparatus where the piping is designed as shown in Fig. 175 is operated in zero weather with a pressure at the boiler of 2 pounds. Under these conditions the steam would travel through the 2½-inch circuit at a velocity of 40 feet per second, and through the 2-inch circuit at a velocity of 45 feet per second.

We will assume that the boiler is of the vertical sectional type, made of cast iron, and contains 8 square feet of grate and 120 feet of heating surface. Now, if these two steam lines are connected directly to the boiler as is shown in Fig. 176, the velocity of the steam leaving the steam dome will be so high that water will be carried out with the steam through the mains and into the radiators, and beside this the water will be likely to leave the gauge glass as soon as the pressure rises.

It is not improbable that the pioneers in steam heating encountered this difficulty, and to remedy it increased the size of the steam mains, and that this practice has been continued down to the present time under the impression that the piping must be of large size in order to carry the water of condensation along with the steam, and hold a steady water line.

When we consider that a cubic foot of steam at 2 pounds pressure will only occupy about one cubic inch of space when condensed back to water, we are forced to the conclusion that the customary pipe sizes are larger than is necessary, this being particularly true of the return lines.

To maintain a steady water line on a steam boiler with sensitive heating surface and have dry steam enter the mains, it is necessary that the initial velocity from the steam dome should not exceed 12 feet per second, and to accomplish this result in the installation shown here, it will be necessary to take three 4-inch risers out of the steam dome and connect them up as shown in Fig. 177.

By doing this we reduce the initial velocity to 10 feet per second, while the velocity in the pipe circuits remains at 40 and 45 feet per second respectively.

Where boilers are fitted with a steam

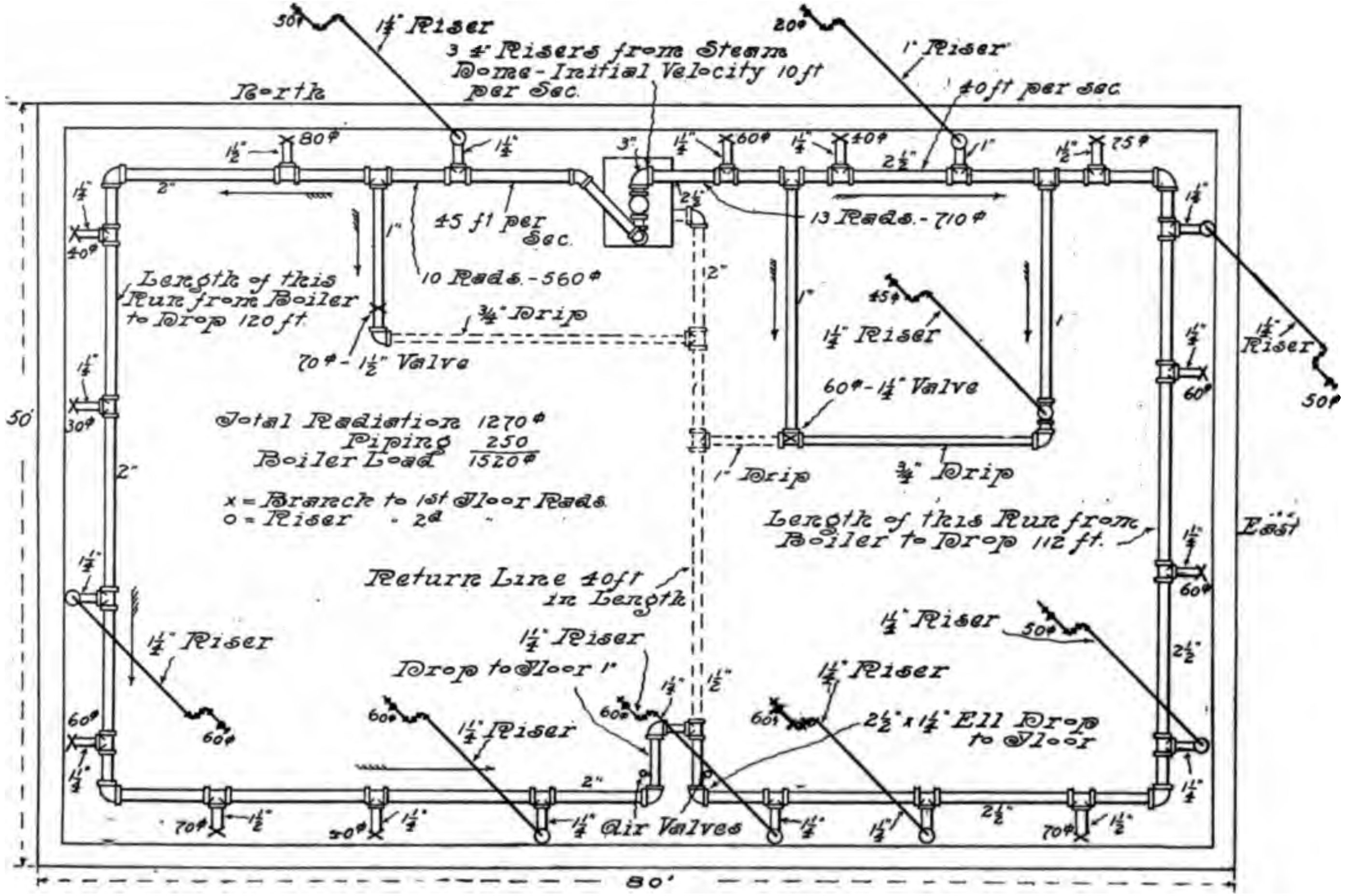


FIG. 175 - ONE PIPE CIRCUIT STEAM HEATING SHOWING PIPE SIZES AND VELOCITY OF STEAM

header and each section has a separate connection to the header, the combined area of the connecting pipes is frequently so limited as to cause a high velocity of steam leaving the dome when the boiler is running under strong fires, and where

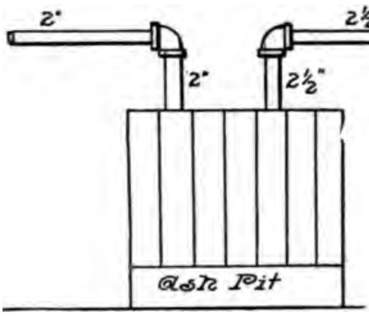


FIG. 176 SIDE VIEW OF BOILER

this occurs there is no remedy, as the conditions are fixed, whereas if a boiler is self-contained and the fitter has made the mistake of not connecting together all of the openings to the steam dome, his error can be easily rectified by connecting to his piping the remainder of the steam outlets.

It is common practice for fitters to bush the size of the openings in steam boilers to conform to the size of the steam mains, and when the apparatus is fired up they find the water will not remain in the gauge glass, while more or

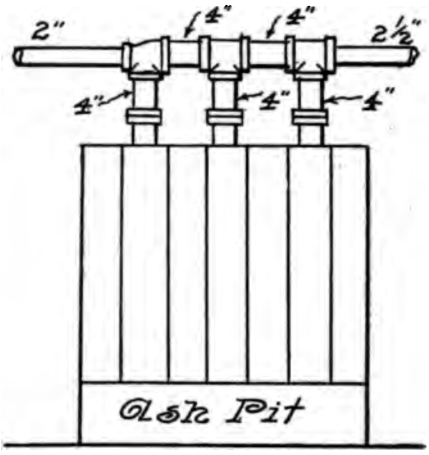


FIG. 177—SIDE VIEW OF BOILER

less water will enter the radiators, causing water hammer. When this occurs, the usual remedy is to put check valves on the returns, supposing that the water in the radiators has been forced out through the returns by unequal pressure. The writer is not prepared to say that this

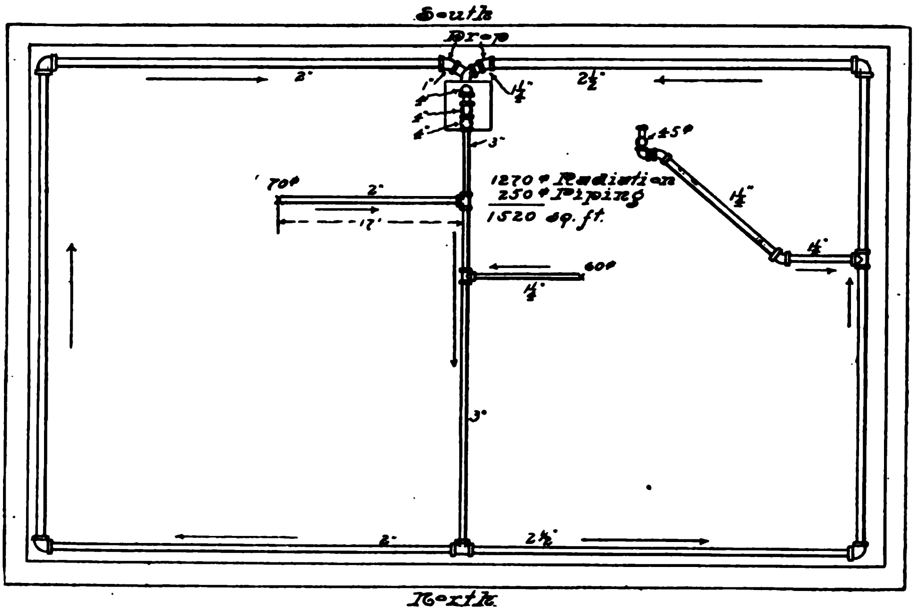


FIGURE 178—SYSTEM OF PIPING ONE PIPE CIRCUIT LOW PRESSURE STEAM

does not happen in isolated cases, but he is prepared to affirm that in the great majority of complaints of water hammer, it is caused by a spray of water being carried into the steam pipes by the initial velocity of the steam leaving the steam dome, and not by water forced out of the boiler through the returns.

Referring again to Fig. 175, it is not necessary that the return pipe should come back to the boiler directly under the floor.

The two returns may be carried overhead side by side back to the boiler if conditions are such as to make that the more desirable method. If there is no wet return the drips from the radiators in the inside of the building must be carried back to the boiler.

In Fig. 178, the piping is arranged in a different manner. Here it is assumed that the boiler is located on the south side of the building, while the prevailing winds come from the north, and it is desirable that the coldest side of the building be the first to receive the steam, consequently a 3-inch pipe is carried from the boiler to the opposite side of the building where it divides and returns to the boiler in two circuits.

In this arrangement the radiators on the inside of the building are connected directly into the main. The arrangement of piping shown in Fig. 178 we consider better practice than that shown in Fig. 136, but it is not always possible to arrange it in this manner.

In all of these sketches the pipe pitches down as the arrows point, and with the exception of the lateral arms to the radiators and risers, the steam and water flow in one direction.

In Fig. 178 there is shown a radiator connection in the middle of the building containing 70 square feet. This radiator connection stands 17 feet from the main, and to obviate the necessity of a drip pipe this branch arm is 2-inch pipe. This makes the pipe large enough to carry the steam in one direction and the water in the other direction without noise.

In this piping system, Fig. 178, the velocity of steam leaving the boiler through the three 4-inch risers will be 10 feet per second; through the 3-inch pipe it will be 47 feet per second; through the 2½-inch it will be 38 feet per second, and through the 2-inch line 40 feet per second.

CHAPTER XLII.

SMALL PIPING FOR STEAM-HEATING APPARATUS—SPACE OCCUPIED BY WATER OF CONDENSATION.

As an illustration of the capacity of a 1½-inch pipe on low pressure steam apparatus, we show in Fig. 179 an isometric view of the piping plans of a small steam heating plant, which was installed the past winter in a small building.

On this job there are twelve radiators containing 510 square feet. The length of piping, which is carried in one circuit around the buildings, is 185 feet, and the square feet of mains, risers, etc., amount to 97 square feet, making a total of 607 square feet, which is attached to the boiler. The pipe rising from the boiler is 3 inches in diameter. At the top of this 3-inch pipe is placed a tee, which is 3 x 1¼ x 1½ inches. The 1½-inch steam main is carried around the basement and back to the boiler, terminating in an ell 1½ x 1 inch. The 1-inch pipe is carried down and connected to the return of the boiler. This job was put in experimentally, and so far is working in a very satisfactory manner. The circulation of steam through the pipe is very rapid. With 2 pounds gauge pressure at the boiler, and all the radiators in service, the velocity in the 1½-inch pipe leaving the 3-inch riser is 60 feet per second. The velocity of the steam leaving the boiler is reduced to 16 feet per second by the use of the 3-inch riser.

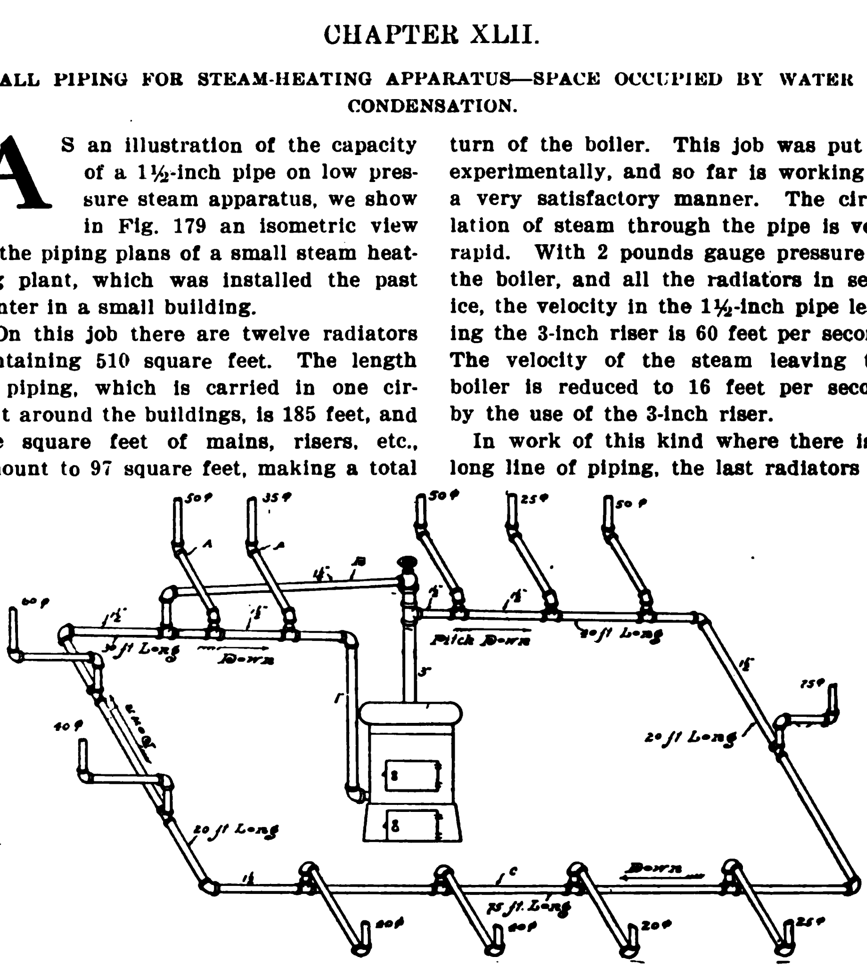


FIG. 179—PIPING PLAN SHOWING TWELVE RADIATORS, 510 SQ. FEET CARRIED ON A ONE AND ONE-HALF INCH CIRCUIT. LENGTH OF PIPE LINE, 185 FEET

In work of this kind where there is a long line of piping, the last radiators on the line will not heat when the boiler is operated at vapor, and to obviate this difficulty the 1¼-inch "booster" pipe "D" was taken from the top of the 3-inch riser and connected into the return end of the steam main, as shown on the plan. This was also somewhat of an experiment, but in this particular job the operation of it is very satisfactory. It is found, however, if steam is generated rapidly and turned into the radiators when they are cold, the valve on the "booster" pipe must be closed until the radiation is filled with steam, after which the valve may be safely opened. If the "booster" pipe valve is open while the radiators are filling, water is likely to on the plan. After the pressure is gone, if the "booster" pipe is open the last radiators on the line will heat equally as well as the first, which is certainly a decided advantage.

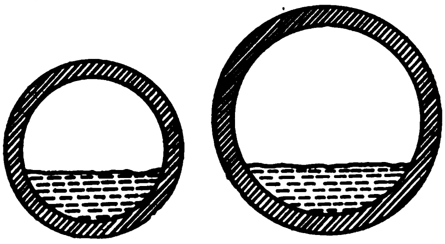

3-4 INCH PIPE 1 INCH PIPE

FIG. 180—SHOWING SPACE OCCUPIED BY CONDENSATION FROM 560 SQ. FT. CONDENSING SURFACE

This plan in Fig. 179 is not shown as a model heating job, but as an illustration of the possibilities of using smaller pipe than is customary in low-pressure steam heating. It would have been better in this particular installation to make two circuits and carry two lines of 1½-inch pipe off the 3-inch riser, in opposite directions, until they meet at the center of the basement opposite the boiler, marked "C" on the plan, where they could be returned to the boiler overhead in two ¾-inch return pipes, and connected together below the water line. If the pipe had been run in two circuits as just described, there would be no necessity for the "booster" pipe.

The question frequently arises as to the proper size for return mains, and in some shops it is the practice to run the return main line one size smaller than the steam line. In other shops the practice is to use for the return line, two sizes smaller pipe than for the steam line. It might be a surprise to some if they could see the space occupied by the water of condensation in an overhead return pipe. In Fig. 180 a 1-inch pipe and a ¾-inch pipe are shown full size, and in each pipe is shown the space occupied by the water of condensation from 560 square feet of condensing surface, that is, radiation and piping.

The average temperature of the air surrounding the radiation at the time this test was made was 68 degrees F. The volume of water shown in these pipes would just about fill a ⅜-inch pipe, Of course, we do not say that a ⅜-inch pipe, or even a ½-inch pipe would be the proper size to use, but we do say that ¾ inch is of ample size.

CHAPTER XLIII.

SIZES OF STEAM MAINS COMPUTED FROM THE VELOCITY OF STEAM IN THE PIPE.

SIZES given are for one pipe carrying steam and its condensation in the same direction.

When the water returns against the flow of the stream, larger pipe must be employed.

The frictional resistance in pipes has been computed and is provided for in the table of "Velocities and Capacities," up to the following lengths:

1¼ inch and 1½ inch......	125 ft.
2 inch and 2½ inch......	250 ft.
3 inch to 4½ inch......	450 ft.
5 inch and 6 inch......	700 ft.
7 inch and 8 inch......	1,000 ft.
9 inch and 10 inch......	1,500 ft.

The velocity table contemplates two pounds initial pressure, 23 cubic feet, as the volume of one pound of steam at two pounds pressure, and the condensing power of the radiation and piping 0.25 pounds per square foot per hour. Each square foot of piping must be counted as condensing surface.

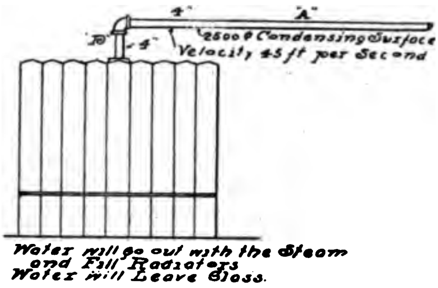

4"
"A"
10"
4"
2500 # Condensing Surface
Velocity 45 ft per Second
Water will go out with the Steam and Fill Radiators
Water will Leave Gloss.

FIG. 181—DIAGRAMS SHOWING PROPER AND IMPROPER METHODS CONNECTING STEAM MAIN WITH STEAM DOME

The velocity of steam through the pipes is governed by the resistance of the atmospheric pressure when the steam is discharged into the atmosphere, and by the rate of condensation and the initial pressure when attached to radiation.

The internal area of steam pipes in square inches and square feet is as follows:

Internal Dia., Inches.	Internal Area, Sq. ~~Ft.~~ IN.	Internal Area, Sq. Ft.
1	0.8626	0.006
1¼	1.496	0.0104
1½	2.038	0.0141
2	3.356	0.0233
2½	4.784	0.0332
3	7.388	0.0513
3½	9.887	0.0687
4	12.73	0.0884
4½	15.96	0.1108
5	20.00	0.1388
6	28.88	0.2006
7	38.73	0.269
8	50.04	0.3474
9	62.73	0.4356
10	78.84	0.5474

The volume of one pound of steam at different pressures, is as follows:

Gauge Pressure, Lbs.	Volume, Cu. Ft. in 1 Lb.
0.	26.36
.304	25.78
1.3	24.33
2.3	22.98
5.3	19.72
10.3	16.00
15.3	13.48
20.3	11.66

Any velocity is safe in low-pressure steam heating that will not lift the water out of the boiler. The greatest economy and highest efficiency is realized where the piping is designed to give a high velocity in the distributing lines and a low velocity of steam leaving the boiler, and where steam is not admitted to the return lines to be condensed and re-evaporated at the boiler. If a 2-inch pipe is used to carry 600 sq. ft. of radiation, the velocity will be 40 ft. per second. For a boiler of 600 ft. capacity, 10 or 12 ft. per second is high enough for the velocity. Therefore, one 4-inch or two 3-inch or three 2½-inch pipes should be used to connect the steam line to boiler dome. If 4,000 sq. ft. of radiation is carried on a 4-inch line, the velocity will be 72 feet per second, and three 5-inch pipes should be used to connect the 4-inch steam line to the boiler dome, which will give an initial velocity of 15.5 ft. which is high enough for a boiler of four or five thousand feet capacity. Few low pressure house-heating boilers of any size will deliver dry steam when the initial velocity exceeds 20 ft. per second. (See Figures 181, 182, 183.)

If the heating trade should adopt this principle, there would be less complaint of "water backing out of the returns." The water *does not* leave the boiler through the returns but through the steam supply pipe, which is *always due* to an excessive initial velocity. In the following table, it is assumed that the ends of all pipe shall be reamed so that the full area of the pipe shall be available. Nothing but oil should be used to lubricate the pipe joints. Red lead and other dope is no better than clear oil, and is likely to fill up the pipe.

VELOCITIES AND CAPACITIES OF LOW-PRESSURE STEAM OR SUPPLY MAINS AND RETURNS.

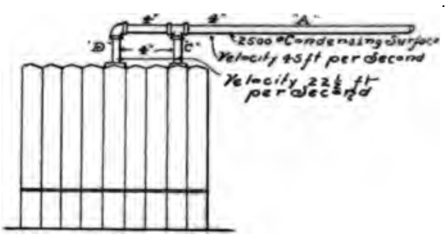
Size of Steam Main, Inches.	Size of Return Main, Inches.	Velocity in Ft. per Second in Steam Line.	Lbs. Steam per Hour.	Square Feet Condensing Surface.
1¼	½	39	62.5	250
1½	½	40	87	350
2	¾	41	150	600
2½	¾	60	312	1250
3	1	62	500	2000
3½	1	65	700	2800
4	1	72	1000	4000
4½	1¼	78	1350	5400
5	1¼	84	1800	7200
6	1½	88	2760	11000
7	1½	95	4000	16000
8	2	100	5500	22000
9	2	110	7500	30000
10	2	116	10000	40000

The velocity of steam passing through a steam pipe per second, may be computed when the quantity of steam passed per hour is known; when this cannot be weighed, it may be calculated by the rate of condensation in the radiation and piping attached.

Process.—Multiply the condensation in pounds by the volume in cubic feet corresponding to the pressure, which will give the volume of steam passing through the pipe in one hour. If the orifice has an area of one square foot, then the volume of steam in cubic feet will be the velocity per hour.

To ascertain the velocity per second, divide the hourly velocity by 3,600, which is 60 x 60, and divide the quotient by the area of pipe in square feet, which gives the velocity in feet per second.

Example 1.—A 4-inch pipe is attached to 2,200 square feet of radiation, which condenses the steam at the rate of 0.25 pound per square foot per hour. The gage pressure is 2 pounds. What is the velocity of steam in feet through the pipe, per second?


4"
4"
"A"
"D"
4"
"C"
2500 # Condensing Surface
Velocity 45 ft per Second
Velocity 22½ ft per Second

This will work all right, except in Boilers with Sensitive Heating Surface

FIGURE 182

Answer.—2,200 times 0.25 equals 550 pounds steam per hour.

550 times 23 equals 12,650 cubic feet per hour.

12,650 divided by 3,600 equals 3.52 cubic feet per second.

3.52 divided by .0884 equals 39.8 feet velocity per second.

Example 2.—In testing blast heater sections, it was found that a 4-inch pipe, 20 feet long, conveyed 2,500 pounds of steam per hour when the initial pressure was 2 pounds. The velocity in feet per second is $\frac{2{,}500 \times 23}{3{,}600 \times .0884}$ which equals 180 feet per second. How much direct radiation will a 4-inch pipe carry, working under above conditions?

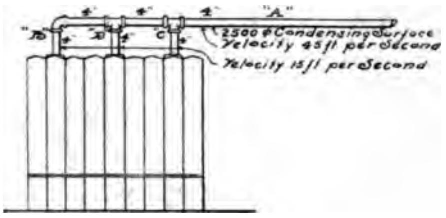
Answer.—$\frac{2,500}{0.25}$ equals 10,000 square feet.

This would not be good practice, but it shows the possibilities of pipe sizes.

Example 3.—One 4-inch pipe attached to a boiler, carries 850 pounds of steam per hour at atmospheric pressure. What is the velocity of steam in the pipe per second?

Answer.—$\frac{850 \times 26.36}{3,600 \times .0884}$ equals 70 feet per second, and 850 pounds of steam per hour will supply 3,400 square feet of radiation.

Example 4.—A 10-inch pipe carries 10,000 pounds of steam per hour under 10 pounds pressure. What is the velocity in the pipe?


4"
4"
4"
"A"
"B"
"D"
"C"
4"
4"
4"
2500 # Condensing Surface
Velocity 45 ft per Second
Velocity 15 ft per Second

In this sketch, the Initial Velocity Drops to 15 ft. per Second, which will insure Dry Steam

FIGURE 183.

Answer.—$\frac{10,000 \times 16}{3,600 \times 0.55}$ equals 81 feet per second, and 10,000 pounds of steam per hour will supply 40,000 square feet of radiation.

SHORT METHOD OF COMPUTING VELOCITIES.

For two pounds gage pressure, multiply the radiation and piping in square feet by the factor 5.75 (the product of 0.25 times 23), which shows in cubic feet the quantity of steam condensed per hour by the condensing surface.

To obtain the velocity in feet per second, divide the product by 3,600 times the area of the pipe in square feet, thus:

Size of Pipe, Inches.	Area, Sq. In.	Area, Sq. Ft.	Divisor for Cu. Ft. Steam 3600 Times the Pipe Area.
1	2	3	4
1¼	1.496	0.0104	37
1½	2.058	0.0141	50
2	3.356	0.0233	84
2½	4.784	0.0332	119
3	7.388	0.0513	184
3½	9.887	0.0687	247
4	12.73	0.0884	318
4½	15.961	0.1108	398
5	19.99	0.1388	499
6	28.888	0.2006	722
7	38.738	0.269	968
8	50.04	0.3474	1250
9	62.73	0.4356	1568
10	78.839	0.5474	1970

Example 1.—3,900 square feet of radiation is supplied by a 4-inch steam pipe; boiler gage pressure is 2 pounds. What is the velocity per second?

Answer.—$\frac{3,900 \times 5.75}{318}$ equals 70 feet.

Example 2.—1,800 square feet of radiation is to be carried on one circuit; steam and condensation carried in same pipe; pipe uncovered; computed velocity in supply lines 60 feet per second. What size pipe may be selected?

Answer.—1,800 plus 20 per cent. for mains, equals 2,160 square feet of condensing surface. 2,160 × 5.75 equals 12,420 divided by 60 feet per second, equals 207 for divisor (col. 4). In the divisor column, the number 207 comes between 3 inch (184) and 3½ inch (247). If the circuit is 250 feet or less in length, use 3-inch pipe, if more, use 3½ inch.

CHAPTER XLIV.

STEAM AND WATER PIPE SIZES.

J. R. asks for a solution of the following problems: First—Give a reliable rule for figuring the correct size of mains and branches for water and steam heating, low pressure.

Second—Show the best method of taking branches from flow and return mains, and give illustrations of the different methods.

Third—Is it essential in water heating that flow and return branches have exactly the same number of fittings?

Fourth—When reducing a hot water main where a branch is taken off to supply a radiator on the second floor, if the flow branch is taken out of the side of the main, will it not leave an air pocket? For example: If the main is 3 inches, and is reduced by a 3 x 2½ x 1½ tee and a 1½-inch branch is taken out of the side, will there not be a pocket between the top of the 1½-inch branch and the top of the 3-inch main?

In answering our corespondent's question in regard to pipe sizes, we might say there are a great many rules for obtaining the sizes of pipe for various amounts of radiation. These rules are apparently obtained by selecting a number of steam or water heating jobs which seem to be giving satisfaction, and then by comparison of the area of the pipes with the quantity of radiation attached, a rule is established, based on those proportions, which is handed out to the trade as being a safe rule to follow. Work installed by such rules may work satisfactorily, but possibly and very probably, pipe one-half the area would work equally as well, or better, and save a lot of expense.

These rules are usually formulated by men of limited practical experience, who do not care to take any chances on theories that they do not see backed up by actual practice.

A common rule in use for obtaining the sizes of low-pressure steam mains is to square the diameter of the pipe and call the product "square feet of radiation," thus:

The capacity of a 3-inch pipe would be 3 multiplied by 3 equals 9, or 900 square feet of radiation.

Then there are some that take 75 per cent of the squared product; other take 80 per cent, other again take 90 per cent.

The following rule for low-pressure steam mains, one-pipe work, may be found in a number of fitters' hand books published by various manufacturers and jobbers.

Piping.	Radiation.
2 inch	300 square feet
2½ inch	500 square feet
3 inch	800 square feet
3½ inch	1,200 square feet
4 inch	1 800 square feet
4½ inch	2,500 square feet
5 inch	3,000 square feet

The reason that such large sizes of pipe ever came into use is because the early steam fitter found that when he connected a certain size of pipe to the dome of the steam boiler and hooked up his radiation, water was carried into the system with the rising pressure of steam.

The only remedy he could think of was to enlarge his piping until a size of pipe was installed which worked dry, and in that way the current pipe sizes came into use.

Numerous experiments and installations made within the past few years show that pipe sizes may be cut down to one-half and one-third the usual size, without lowering the efficiency of the apparatus in any particular. To do this, however, it is absolutely necessary that large and numerous openings be taken out of the steam dome of the boiler, so that the velocity of steam leaving the steam dome will be low enough not to carry with it any water.

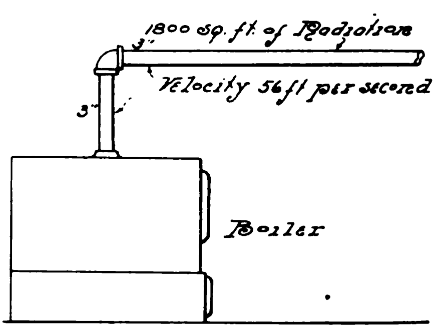


FIG. 184 CONNECTING RISER TO THE BOILER

We will suppose that a 3-inch main is employed to convey steam to 1,800 square feet of radiation. The radiators are connected to the main with one pipe and the steam and water flow together. The velocity of steam in a 3-inch pipe, with 1,800 square feet of radiation attached, with 2 pounds pressure, is 56 feet per second, and if but one 3-inch pipe is attached to the steam dome of a boiler, this high velocity will carry water out with the steam and into the radiation.

If we connect up another riser out of the steam dome, of the same size as the other, we lower the velocity of the steam, leaving the boiler to 28 feet per second, which is still too high.

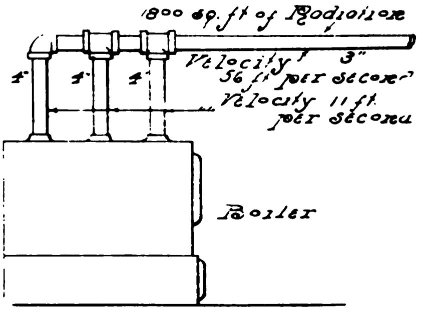


FIG. 185 CONNECTING RISER TO THE BOILER

If we take three 3-inch pipes out of the steam dome, the velocity drops to 18.7 feet per second as it leaves the boiler, but will continue in the main at 56 feet per second as long as the rate of condensation in the radiation is sufficient to draw the volume of steam which causes the velocity. Three 4-inch risers from the steam dome connected to the 3-inch main will lower the initial velocity to 11 feet per second, which would be still better practice.

See Figures 184, 185, and 186, which illustrate this principle.

If care is taken to maintain a low velocity of steam leaving the boiler, the following pipe sizes may be used.

Pipe Sizes for One Pipe Steam, Water and Steam Flowing in Same Direction.

Steam Main, inches	1½	2	2½	3	3½	4	4½	5
Return to boiler	¾	1	1	1¼	1½	1½	1½	2
Radiation, sq. ft	350	600	1250	1900	2500	3900	4800	6900

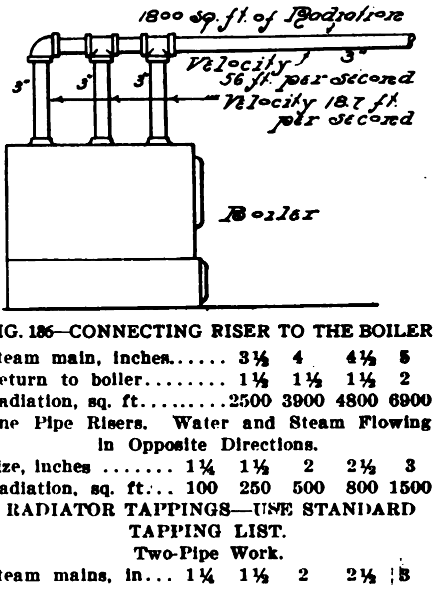


FIG. 186—CONNECTING RISER TO THE BOILER

One Pipe Risers. Water and Steam Flowing in Opposite Directions.

Size, inches	1¼	1½	2	2½	3
Radiation, sq. ft.	100	250	500	800	1500

RADIATOR TAPPINGS—USE STANDARD TAPPING LIST.

Two-Pipe Work.

Steam mains, in.	1¼	1½	2	2½	3
Return, inches	¾	¾	1	1	1¼
Radiation, sq. ft.	300	500	1100	1800	2500

Steam mains, inches	3½	4	4½	5
Return, in.	1½	1½	1½	2
Radiation, sq. ft	3200	4500	5500	8000

Two-Pipe Risers.

Steam, inches	¾	1	1¼	1½	2
Return, inches	½	½	¾	¾	¾
Radiation, sq. ft.	50	100	200	400	600

Radiator Tappings.

60 sq. ft. and less	¾ x ½ inch
65 sq. ft. to 100 sq. ft.	1 x ½ inch
Above 100 sq. ft.	1¼ x ¾ inch

Some may think it a great hardship to connect more than one opening from the steam dome of a boiler to one line of pipe, and claim that it is an expense they had not figured on, but they will find by experience that the saving in cost of pipe sizes and labor will more than offset the cost of boiler connections.

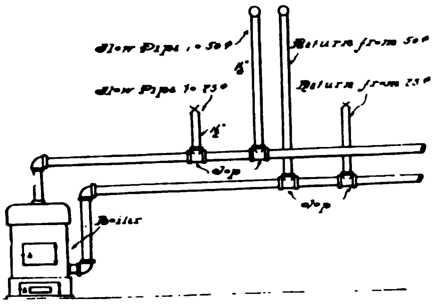


FIG. 187—WRONG METHOD OF WATER HEATING CONNECTION. THE RETURN WATER FROM 50 SQ. FT. WILL ENTER THE RETURN FROM 75 SQ. FT. AND STOP CIRCULATION

As a matter of fact, the average steam fitter knows nothing about the velocity with which steam travels in a steam pipe, and this method of maintaining a high velocity in the steam lines and a low initial velocity at the boiler has never received from the heating contractor the consideration it deserves.

If the steam-heating fraternity would put a little thought into better methods of installation, they would not only make more money in their business, but they would make steam and water heating more popular, because they would be in a position to do it for less money.

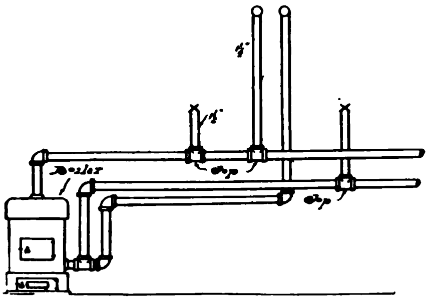


FIG. 188—A REMEDY FOR THE DEFECTIVE CONNECTION SHOWN IN FIG. 187

For water heating mains we submit the following sizes, which have been used successfully in practice.

Pipe Sizes for Water Heating. Flow and Return Same Size.

Size, inches	1¼	1½	2	2½	3
Basement Work.					
Two-pipe	100	200	500	700	1100
One-pipe circuit		150	350	500	750
Overhead System.					
Main riser		300	600	1200	2000
Size, inches	3½	4	4½	5	6
Basement Work.					
Two-pipe	1450	1900	2400	3000	4300
One-pipe circuit	1050	1350	1650	2000	3000
Overhead System.					
Main riser	2500	3500	4500	6000	10000

Risers.

Size, inches	¾	1	1¼	1½	2	2½
From basement up feed—						
Two pipes	50	80	150	250	600	1200
From attic down feed—						
One pipe	50	100	225	300	750	1500

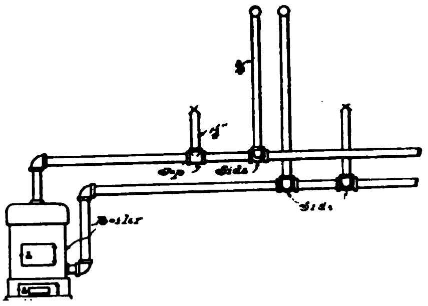


FIG. 139—THE PROPER CONNECTION WHICH WILL GIVE EVEN CIRCULATION

Radiator Tappings for Water Heating.

Basement work, first floor—To 25 sq. ft. ¾ inch, to 80 ft. 1 inch, to 100 ft. 1¼ inch.

Basement work, upper floors—To 40 sq. ft. ¾ inch, to 100 ft. 1 inch, to 200 ft. 1¼ inch.

Overhead system, top and bottom—To 50 sq. ft. ¾ inch, to 100 ft. 1 inch.

In regard to radiator tappings, the standard list is probably about right for one-pipe work, steam, but for two-pipe steam work it is much larger than is necessary, and for water heating the sizes should be reduced, especially for radiators on the upper floors.

The manufacturers must, of course, adopt some list for tapping, and they incline to the large sizes because many of their customers insist on having them large, and it is impossible to manufacture radiators in large quantities and wait until the orders come in for the tapping. They are, however, arranged so that they can be bushed down to any size desired. The sizes given in this table for both steam and water heating have been used with good results in practice.

In one-pipe steam work it does not seem to make much difference how the branch is taken off the main. Many people use a 45-degree ell, claiming that by this method the water of condensation will drop into the bottom of the main without interfering with the outgoing steam.

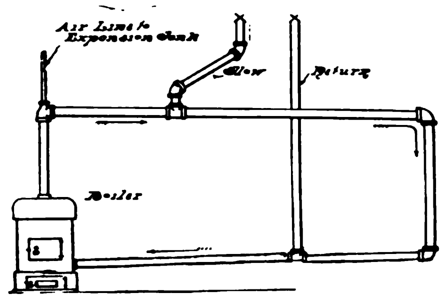


FIG. 190—FALLING CIRCULATION, AIR VENT AT BOILER

It would probably be a surprise to most heating men if they could see the very small amount of condensation that comes back from a radiator or a line of radiators. It is so small that it clings to the side of the pipe, and whether the pipe is taken out of the side of the main or out of the top of the main, or at an angle of 45 degrees, the condensation will cling to the side of the pipe until it reaches the bottom of the main. The writer's method is to use comparatively small mains and take most of the branches from the top of the main.

In water heating it is as a rule good practice to take the flow pipe from the main at an angle of 45 degrees, or from the side if main is small, which permits a film of water to flow undisturbed to the end of the main pipe.

If the branch for the first radiator is taken off the top of the pipe, it receives the first flow of heated water from the boiler, and the next radiator does not heat until a deeper strata of water in the pipe is warm. Then again it frequently happens that the branch taken from the top of a feed-water main is so large that circulation will not take place beyond that point until the water has attained a higher temperature than is necessary. Considering this, we believe it is good practice to take the feed for the first few radiators out of the side of the main, while the returns should always enter the side of the return main. It is the return water from radiators on the upper floors which usually causes imperfect circulation. We will suppose that a radiator on the upper floor contains 50 square feet; the one below it 75 square feet. The risers to the upper floor may be 1¼ inches. The heated water goes through the upper radiator very rapidly, and drops into the return main at a comparatively high temperature, and before circulation is established in the 75-foot radiator. Then, instead of flowing along the pipe toward the boiler, the return water enters the return of the 75-foot radiator, where it meets a counter-current from the flow pipe and the circulation in the radiator is stopped.

To prevent occurrences of this kind, the riser to the upper floor should not be larger than 1-inch, and if near the boiler ¾-inch. It should be taken from the side of the flow pipe and returned into the side of the return main. In aggravated cases of this kind, where the work is already installed, the quickest and most effective cure is to carry the offending return pipe back to the boiler. See sketches Nos. 187, 188 and 189.

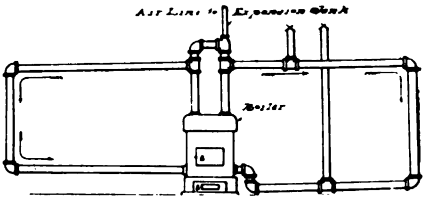


FIG. 191—FALLING CIRCULATION. TWO CIRCUITS AIR VENT AT BOILER

Where a pipe reduces from 3 to 2½ inches, or any other reduction, and the flow pipe is taken off at a 45 angle, there is unquestionably a small air trap formed in the larger pipe. Such reductions should never be made in hot water heating if they can possibly be avoided, as they will invariably cause trouble, and the trouble is caused by the stoppage of the flow of water along the top of the pipe at that point, which will enter and flow through the branch line easier than it will through the smaller main.

A better method is to continue the pipe size until an elbow is reached, where the reduction can be made with less danger of impeded circulation. It is true that theoretically the reducing elbow will leave a certain amount of air in the top of the 3-inch main, but in this case it will not do any particular harm, as it is compressed into a very small volume by the head of water.

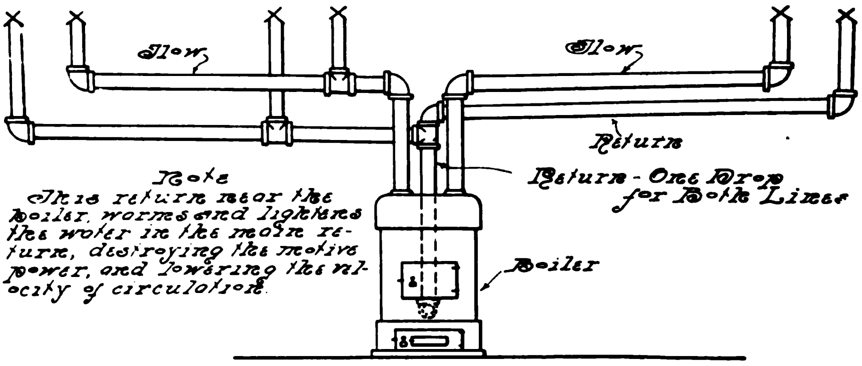

Flow
Flow
Return
Return - One Drop for Both Lines
Boiler
Note
This return near the boiler, warms and lightens the water in the main return, destroying the motive power, and lowering the velocity of circulation.

FIGURE 192—RISING CIRCULATION, THE METHOD OF BASEMENT PIPING

The best method of basement piping for water heating is to make the high point at the boiler, pitching down to the further end of the line, then dropping to or near the basement floor and returning to the boiler. The air can be taken off by a small pipe line connected to the expansion pipe. In this method the pipe is usually run without any reduction in size. There is no air in the way, and the return lines, dropping to or near the basement floor, produce a more rapid circulation than can be obtained in the ordinary method, and beside this each line of pipe from the boiler carries its own motive power; that is to say where there is but one return from the boiler, the motive power obtained at that point must act for the entire system, whereas if the system is divided into different lines, each line having its own drop, a more rapid circulation is secured and the job or the work will be more efficient throughout. See sketches Nos. 190, 191, 192. These are mere outline sketches, showing the principle involved.

There is no necessity for having the exact number of elbows or fitting on the flow and return pipes of any kind of a heating apparatus. Of course, elbows, particularly right-angle elbows, cause a certain amount of friction, and the fewer right-angle elbows used the less will be the friction, although the piping may be so constructed as to counteract friction and accelerate the flow of water.

CHAPTER XLV.

PIPE SIZES FOR WATER HEATING APPARATUS.

We have received quite recently a number of letters from correspondents in various parts of the country asking for a reliable rule for figuring the correct sizes of pipe and radiator valves for water-heating apparatus.

The theoretical pipe sizes for water-heating apparatus to produce given results have been carefully figured, the calculations being based on the velocity of the flow of water through the pipes, the frictional resistance and the loss of heat.

If a water-heating apparatus is installed in accordance with those theoretical pipe sizes, and return connections are so arranged that the water from the main return will not enter the return end of some of the radiators, the apparatus will apparently work satisfactorily; that is, the temperature of the radiation will probably be within ten or fifteen degrees of the initial temperature at the boiler, and unless there is an opportunity for comparison with an apparatus of equal size but using smaller pipe, it might easily be supposed that such an apparatus could not be improved upon.

The heating contractor, however, who does a large number of water-heating jobs, soon learns that the theoretical pipe sizes may be cut in two and better results obtained by the substitution. One reason for this is that as the pipe sizes increase the volume of water is increased as well as the cooling surface, and this increases the tax on the boiler. There are many water-heating jobs in operation to-day whose piping is a greater tax on the boiler than is the entire amount of radiation apportioned to warm the rooms.

In some of our cities a heating contractor will sometimes have a contract for heating one hundred cottages, all of the same size, or practically so. These

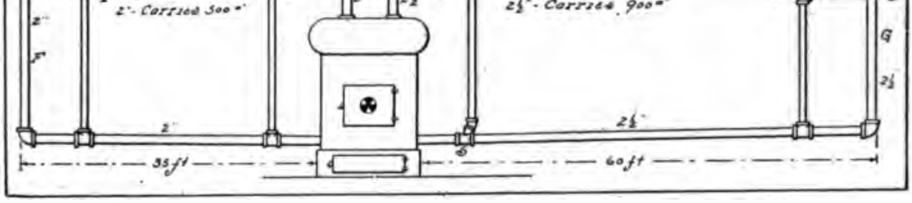


FIG. 193—PIPE DOES NOT REDUCE FROM TIME IT LEAVES BOILER UNTIL IT ENTERS SAME THROUGH THE RETURN

contractors have learned by experience to cut their pipe sizes to the limit, and are now installing work that is satisfactory in every respect while using pipe of less than half the area that was thought necessary when they began to install this kind of work. For example, where they once used a 2-inch main they now use a 1¼-inch main and assert that they not only get as good results, but that the apparatus works more quickly and that less fuel is required. In these cottages it is not an uncommon thing to see a 1¼-inch main carrying 250 feet of radiation, the connections and valves for the radiators being ¾-inch. We do not advocate these extremes, but believe there is a happy medium whereby a large amount of money can be saved in material and in labor as well, because, as every practical man knows, it costs less to cut and fit 1¼-inch pipe than it does to cut and fit 2-inch pipe.

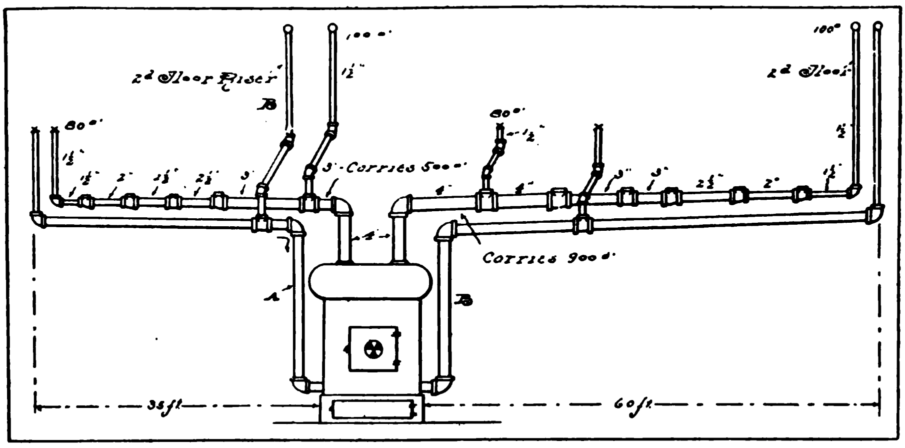


FIG. 194—ANOTHER REASON FOR FEEBLE CIRCULATION IN AN INSTALLATION IS SHOWN HERE

A few years ago every steamfitter who undertook to install a water-heating apparatus thought he must of necessity use long-turn elbows and Ys instead of tees, but he has gradually learned to do without these antiquated fittings. Others again thought that if a right-angle elbow were introduced in the main or branch of a water-heating apparatus, it would refuse to operate, and consequently it became the general practice to insert two 45 ells, a pure waste of time and material.

One of the greatest fallacies in designing the piping for water-heating apparatus is to suppose that the cross area of the main must be equal to the combined area of all the branches. It is only necessary to follow this into large work to see the absurdity of any such theory.

Another superstitious idea advanced by some steamfitters is that all hot-water piping must grade up from the boiler, while, as a matter of fact, the quickest circulation is obtained by grading the flow pipe down from the boiler and connecting the end to the return, making a complete circuit from the top of the boiler to the return, as is shown in Fig. 193.

In this sketch we show two lines of piping leaving the boiler, one 2½-inch and one 2-inch. From the top of these lines, where they leave the boiler, a ⅛ or ¼-inch line is connected and carried to the nearest riser, or, if convenient, to the expansion pipe. This air line, however, may be connected to the riser to a first-floor radiator, as the air will then be extracted through the air valve of the radiator to which it is attached.

In grading the pipe down from the boiler and connecting the ends to the return, carrying the return back on a line with the boiler return, much quicker circulation is obtained than in any other way, except that of the overhead system. The connection between the two extreme ends of the flow and return main furnishes the motive power which causes the circulation.

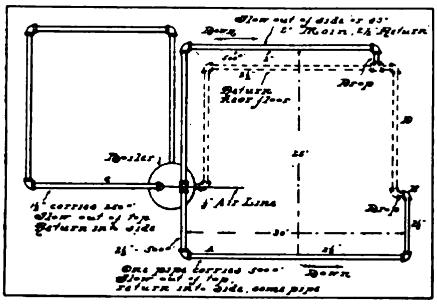


FIG. 195 - A HOT WATER HEATING JOB SHOWING THREE DISTINCT SYSTEMS

The flow connections to the radiators should be taken off the side of the pipe. All the returns should drop down and be connected into the side of the return, whenever such connection is feasible.

We show here a 2½-inch line, 60 feet in length, carrying 900 feet of radiation. On the other line we show a 2-inch main carrying 500 feet of radiation.

An apparatus substantially as shown in this sketch has been in operation for a number of years and giving excellent satisfaction, so there is no question as to the capacity of the pipes shown in this sketch.

In Fig. 194 we show a sketch of the same quantity of radiation run in the usual manner, that is, with the flow and return pipe side by side and grading up from the boiler. The 900 feet of radiation is carried by a 4-inch main leaving the boiler, and the 500 feet by a 3-inch main. These mains reduce from time to time as branches are taken off, and it is in work of this kind that frequent trouble occurs owing to the difficulty of obtaining good circulation at the end of the lines.

One of the causes of this defective circulation is the abrupt reduction in sizes, the heated strata of water frequently refusing to pass a given point until the temperature at the boiler is increased. Thus we frequently see a job of water heating that will work all right so long as the temperature at the boiler is between 180 and 200 degrees, but when it is attempted to operate the plant at a temperature of 140 degrees, many of the radiators refuse to heat. In Fig. 193 the pipe size does not reduce from the time it leaves the boiler until it enters the same through the return.

Another reason for feeble circulation in an installation arranged as shown by Fig. 194, is that the water in the return pipe is heated too soon from the return of the nearest radiator, as is shown in the sketch where the riser *B* enters the main return *A* near the boiler. This water will enter the main only a few degrees cooler than when it leaves the boiler, and will warm the column of water in

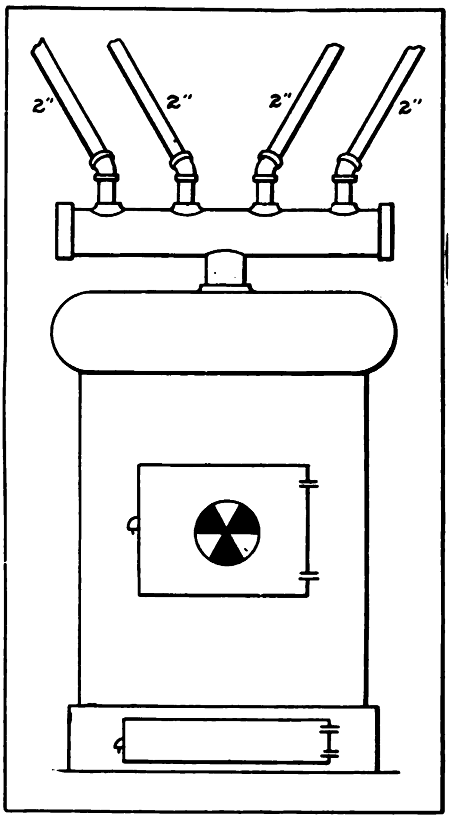


FIG. 196—A WATER HEATER FURNISHED WITH A HEADER FROM WHICH FOUR 2-INCH FLOW PIPES DISTRIBUTE THE WATER

the pipe *A* very rapidly, and as its temperature increases it becomes lighter and loses its power of gravity, so that the ends of the line will work very slowly.

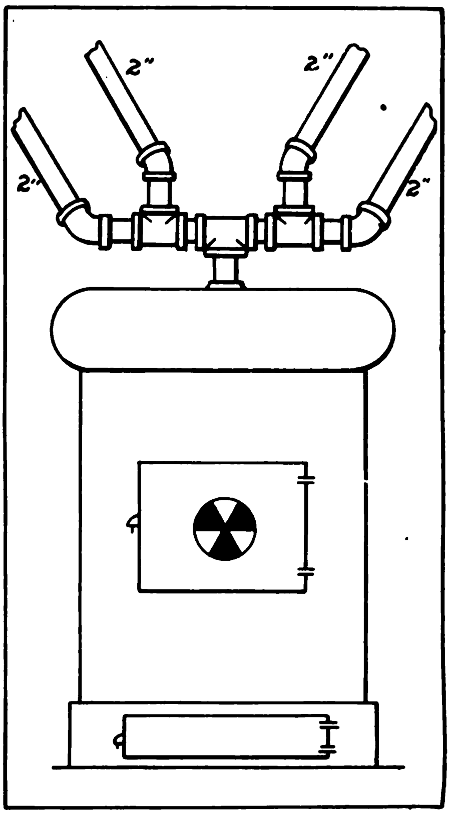


FIG. 197—SHOWS THE WAY THE STEAMFITTER CONNECTED UP THE BOILER WITH A FLANGE

In the main return *B* the radiator return *C* is not connected so near to the boiler, but still it will have its effect in warming and, therefore, decreasing the gravity in the return pipe *B*. When the work is installed as shown by Fig. 193 the 2½-inch drop pipes *F* and *G* being at the end of the line, where the water is coolest and the gravity the greatest, will cause a more rapid circulation of the water throughout the system.

Fig. 195 is a plan of a water-heating job showing three distinct systems. Line *A* is a 2½-inch main carrying 500 feet, where the flow pipe is taken out of the top of the main and the return enters the side of same. At the point marked *E* this 2½-inch pipe drops to a point near the floor line and is carried along the wall back to the boiler. If it is not convenient to carry it above the boiler, it may be dropped beneath the floor and rise to the boiler return, but wherever practicable it is better to carry it above the floor so there will be no lift at the boiler. Line *B* is 2-inch carrying 500 feet. Here the line is utilized to convey the hot water to the radiators, the returns from which enter the common 2½-inch return.

The reason for enlarging line *A* is because it must carry the return water, and must, therefore, have greater area.

The 2½-inch return is of ample size for both lines, inasmuch as a 2½-inch main is sufficient to carry 1,000 feet of radiation the distance shown here, which is approximately about 60 feet.

Line *C* is a 1½-inch main carrying 250 feet of radiation. Here the flow is taken out of the top and returned into the side and drops gradually until it reaches the boiler.

In this installation it will be necessary to connect the three lines where they rise from the boiler into the nearest riser or expansion tank line.

Fig. 196 is a sketch showing a water heater as it was planned to be installed; that is, the heater was furnished with a

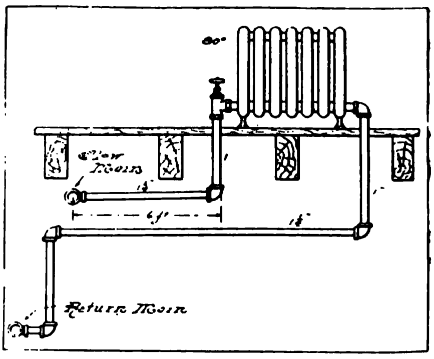


FIG. 198—A GOOD METHOD OF RADIATOR CONNECTION

header from which four 2-inch flow pipes distributed the water to the various radiators. A piping plan was made showing the pipes connected to the header, as in Fig. 196.

In some way the header was lost in transit and the steamfitter, in his extremity, procured a flange and connected the boiler up as shown in Fig. 197. Here one 2-inch nipple about 12 inches in length supplies four 2-inch lines of pipe.

This work was installed about fifteen years ago, and so far as we know is still in operation. We ran across this job after it had been in operation for about five years, and were told that it was operating satisfactorily in every respect.

This theory may be put in practice in radiator connections. It is good practice to run the lateral line to a point underneath the radiator valve and look up one size smaller, as is shown in Fig. 198, where the lateral branch is 1¼-inch and the riser to an 80-foot radiator 1-inch. This system of piping has been in operation for a number of years by some of the best hot-water engineers in this country and will give satisfaction whenever it is put in practice.

The standard tapping lists issued by the various radiator manufacturers are much larger than is necessary; in fact, if the standard tappings are used for second and third-floor radiators and the risers are run the full size of the radiator tappings, there is almost sure to be trouble in the circulation of the radiators on the first floor. The following tapping list for hot-water radiators has been used for a number of years by many good heating men, and provided the pipe is properly proportioned and that red lead or other dope is not used to fill the orifice of the valve, these sizes will be found satisfactory.

First floor—Up feed:	
To 60 square feet	1″ x 1″
To 25 square feet	¾″ x ¾″
To 100 square feet	1¼″ x 1¼″
Second floor—Up feed:	
To 40 square feet	¾″ x ¾″
To 100 square feet	1″ x 1″
To 200 square feet	1¼″ x 1¼″
Overhead system—Down feed:	
To 50 square feet	¾″ x ¾″
To 100 square feet	1″ x 1″

CHAPTER XLVI.

RISERS FOR WATER HEATING APPARATUS.

IN running risers for a hot-water heating apparatus, the average fitter has been taught to believe that he must so arrange his piping as to deflect the flow of hot water into the radiator on an upper floor. His idea is that if some means are not taken to turn the hot water into the radiator, it will flow past and heat only the upper radiator, the lower one in the meantime remaining cold.

Little or no attention is paid to the return pipe, the idea uppermost in the mind being that if the flow of water is diverted into the radiator, the return will take care of itself.

It is because of this belief that so many fitters have trouble with the water heating apparatus which they install from time to time, the heated water from the return of a radiator entering the return of some other radiator and checking the circulation.

It is the weight of the water in the return pipe which causes the heated water to enter a radiator, and if the returns are properly connected in the basement or to the boiler, it will be impossible to prevent the heated water from entering the radiator, and following, by gravity, the denser and cooler water in the return column.

The practice most in vogue in running hot-water risers is illustrated in Fig. 199. Here is shown a four-story building. The first-floor radiator contains 100 square feet; the second-floor, 80 square feet; the third-floor, 80 square feet, and the fourth-floor 100 square feet.

From the main flow pipe a 2½-inch branch runs out beneath the first floor radiator, which is connected with a 1½-inch valve. This connection is taken off the top of the tee, or the top of the pipe, as the case may be. From the side of the tee, a 2-inch riser is carried to the second floor, and here a tee 2 x 1½ x 1½ inches is used. From the top of this tee the second-floor radiator is fed with a 1½-inch pipe and 1½-inch valve. From the side of the tee a 1½-inch riser is carried to the third floor, where a tee 1½ x 1½ x 1¼ inches is used. From the top of the tee a 1½-inch connection is made to the 80-foot radiator, and from the side of the tee a 1¼-inch riser is carried to the fourth floor. Upon the top of this riser is placed a 1¼ x 1½-inch ell, so that the radiator may be connected up 1½-inch. The returns are of the same size as the flow pipe and the connections are made in exactly the same manner.

The fitters who have been in the habit of using this style of connection will assert that if the risers are run as is shown in Fig. 200, nothing but the top radiator will heat. Probably some have tried this method of running the risers straight to the top story and feeding the radiators out of the side of the tee, and have found to their sorrow that some radiators would not heat, but if they had thoroughly investigated the matter they would have found the trouble in the return pipe. It might be that the bottom of the return was connected into the main at a point where it received the water from a line of radiators which delivered their return water at a higher temperature than the temperature of the water in the line that was giving trouble, and this hotter water would enter the cooler return and check the circulation in the whole line. We can, of course, only guess at where the trouble lay, but it is a fact, nevertheless, that a line of risers may be installed as shown in Fig. 200, and give just as good results as it is possible to obtain by running the risers and connections as is shown in Fig. 199, and, of course, the cost of labor and fittings, to say nothing of cutting floors, is much less in Fig. 200 than in Fig. 199.

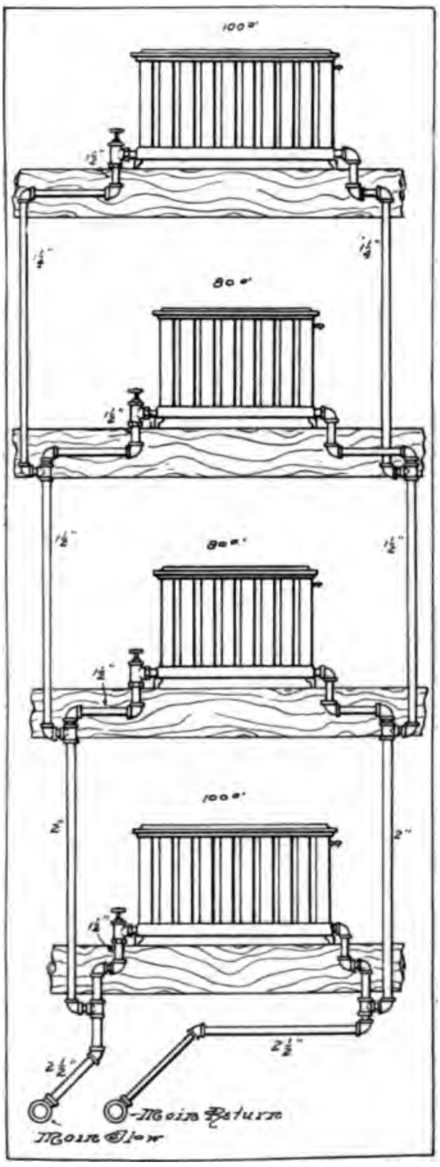


FIG. 199—A COMMON METHOD OF RUNNING HOT WATER RISERS

It will also be noticed that in Fig. 200, which we consider the proper method of piping, the valves on all of the radiators are one-inch. The riser, too, throughout,

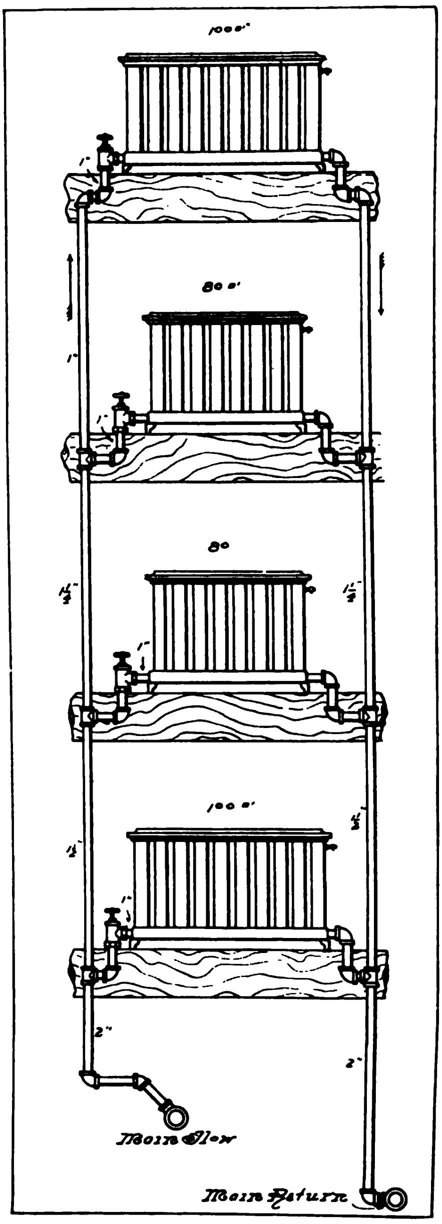


FIG. 200—IF THE RISERS ARE RUN IN THIS MANNER THE CIRCULATION THROUGH EACH RADIATOR WILL BE UNIFORM

is one size smaller than in Fig. 199. This method of piping is not theoretical, but has been used successfully for a number of years by some of the best heating men in the country.

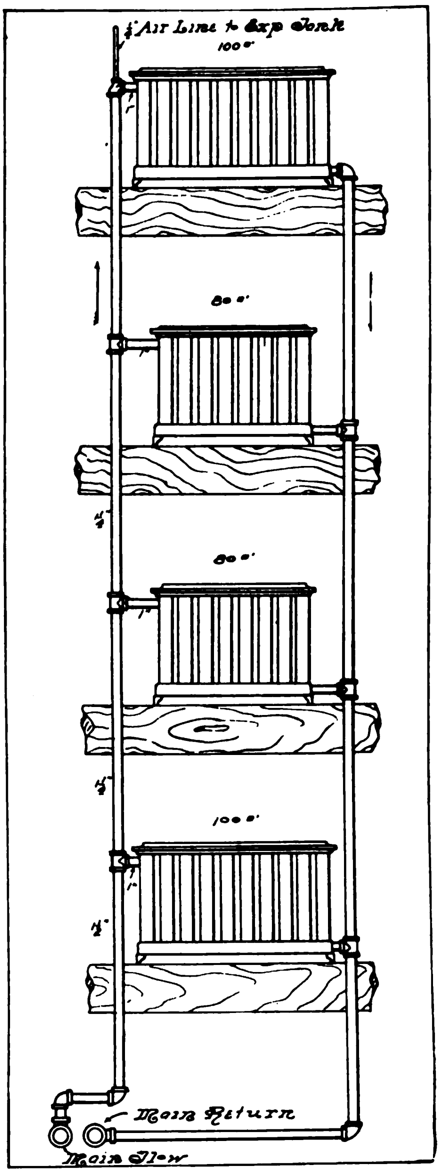


FIG. 201—ANOTHER STYLE OF RUNNING THE HOT WATER RISERS

It is well to note that the return riser in Fig. 200 drops to the main return, which is near the floor line, and connects into side of same. This is the best possible method of connecting the return, where it is possible, but if it is not possible to use the return near the floor line, the return riser should be connected into the side of the main return, whatever position it may occupy.

In Fig. 201 we show the same style of riser as is shown in Fig. 200, with this exception; that the radiators are all connected at the top and from the top of the riser an air line is extended to the expansion tank, which takes care of all the air in the radiators and does away with the necessity of air valves, and for this reason alone is an excellent system to make use of wherever circumstances will permit. It is believed by those who have practised this method of running hot-water risers that they get a more even distribution of the heat through the radiators than when using the bottom connection. Here the main flow and return pipes are shown run side by side, with the flow riser connected to the top of the main, and the return riser entering into the side of the main return.

In Fig. 202 a 1½-inch riser is carried to the top of the radiator on the fourth floor without any connection to the intervening radiators. The fourth-floor radiator may be equipped with an air valve, or an air line may be carried to the expansion tank, as is shown in Fig. 201, the latter being the preferable method wherever it can be adopted. Underneath the fourth-floor radiator there is a by-pass which connects the flow pipe to the return. On the return line the three remaining radiators are connected, top and bottom, into the same pipe, and the riser drops to the return main near the floor line, where it enters on the side.

This method is preferred by some fitters and will always produce rapid circulation, the only objection being the difference in temperature of the water on the various floors. If the water enters the radiator on the fourth floor at 170 deg., the by-pass will furnish a fresh supply of hot water for the radiator on the third floor, so that it will probably receive its feed water at about 2 degrees less than the radiator on the fourth floor. The feed water entering the second-floor radiator will be from 7 to 10 degrees lower in temperature than the one above it, and on the first floor the temperature of the feed water will be from 7 to 10 degrees lower than the second floor. That is, if the fourth-floor radiator receives the water at 170 deg., the third-floor at 168 degrees, the second-floor at 158 degrees, and the first-floor at 148 degrees, there will be a difference of 22 degrees in the feed water of the first and fourth floors, and the radiation must be increased accordingly. This is true of all down-feed systems where but one pipe is employed for the feed and return water, and in this respect Fig. 201 is the better installation.

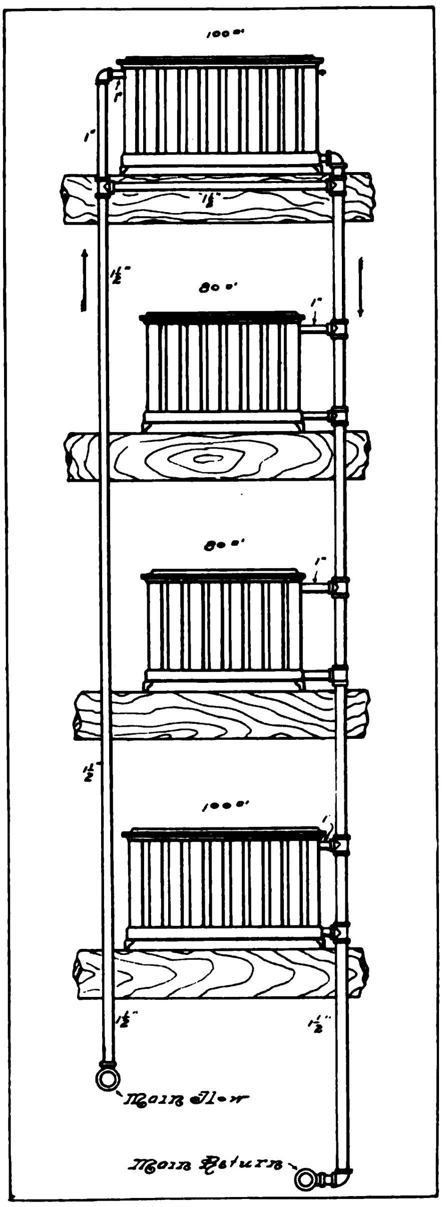


FIG. 202—SHOWING THE RISER CARRIED TO TOP OF RADIATOR ON FOURTH FLOOR

In Fig. 203 we show a four-story building equipped with hot-water radiators, which are fed from a main pipe in the attic. The 2½-inch main riser is intended to be sufficient to feed all the radiators shown in the sketch.

The drop pipe *A* is connected into the main riser in the attic on the side, because if it were connected into the top there would be an air pocket. This riser is 2-inch throughout its length and feeds eight radiators containing 600 square feet. The radiators are fed at the top from a cross placed on the drop line, and the return enters a cross in the same manner under the floor.

Each room on the different floors is supposed to require the same amount of radiation, but inasmuch as the feed and return water is in one pipe, the feed water for the lower floor will be much cooler than for the radiators on the upper floors. The temperature given for the water in risers on the different floors are only an approximation of the temperatures, but it has been found by observation that in many cases the water in a riser connected to a number of radiators, as is shown in riser *A*, will cool from 8 to 10 degrees passing from one tier of radiators to another. For this reason the radiation must be largely increased on the lower floors. In this sketch we show an increase of 50 per cent, which is probably rather more than might be necessary in practice.

The drop pipe, B, is 1½-inch throughout its length and is used to feed the radiators only, there being a separate return of the same size. This is a much better installation than is shown in riser A, because the water will lost a very small portion of its heat in dropping from the fourth to the first floor, therefore there is not the necessity for such a large increase in radiation. It is well, however, to increase the radiation slightly.

Fig. C shows a 1½-inch drop line carrying both the feed and return water, and here again the loss of heat between the fourth and first floors will be very considerable and the radiation must be increased to compensate for this heat loss.

In riser D a 1¼-inch pipe with a separate return is shown feeding three radiators of 40 feet each and one radiator of 50 feet, 170 feet in all, the radiator connections being ¾-inch. In risers A, B, and C, the radiator connections are all 1-inch except the top floor, which is ¾-inch.

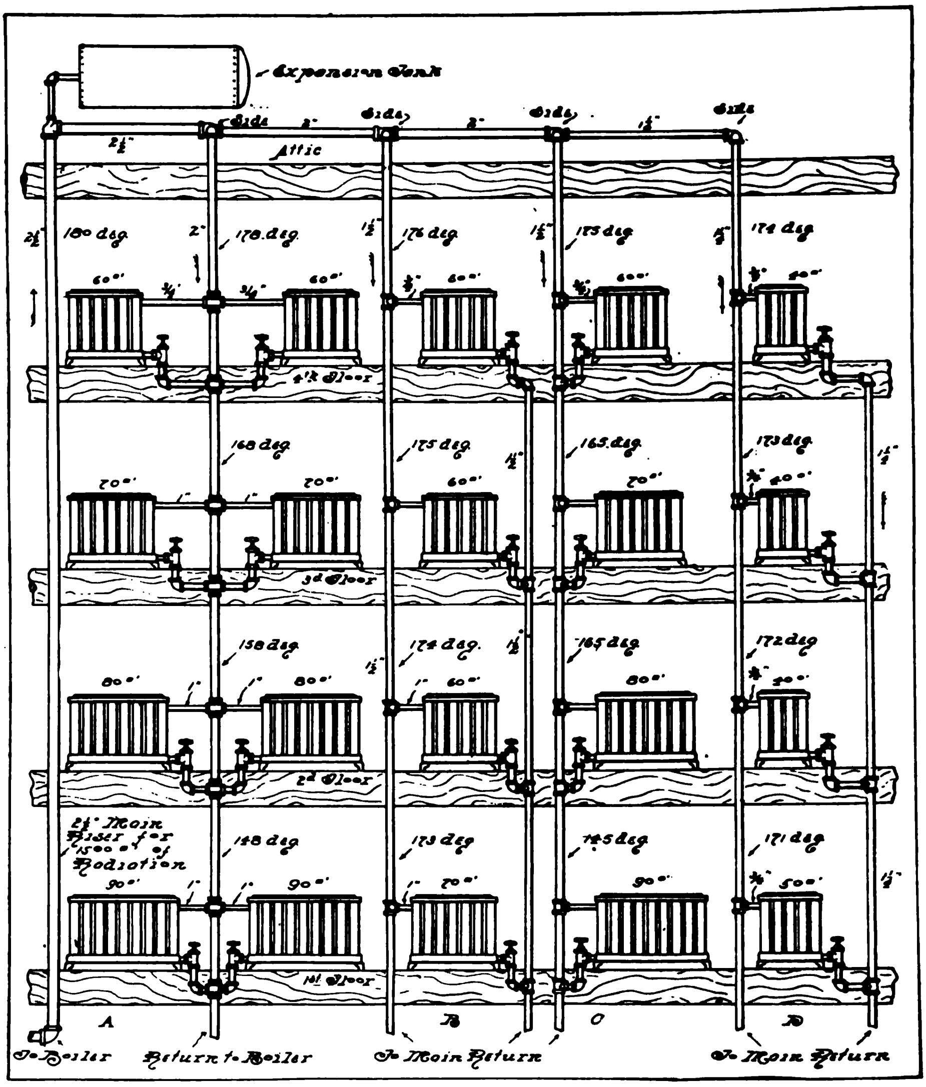


FIG. 203 A FOUR-STORY BUILDING EQUIPPED WITH HOT WATER RADIATORS WHICH ARE FED FROM A MAIN PIPE IN THE ATTIC

CHAPTER XLVII.

EUROPEAN HEATING SYSTEMS.

IN France and Germany, and in some other parts of the continent, a two-pipe system of steam heating is in common use. The difference between the two-pipe steam system in Europe and that employed in this country, is that in this country a pressure is supposed to be carried through the entire system and the radiators are equipped with valves on both supply and return. The return valve must be closed to prevent the pressure carrying the water into the radiators when the supply valve is closed.

The system referred to as being in vogue in Europe carries a pressure on the steam lines only, and there being no pressure on the returns, but one valve is used, and that on the supply pipe. There are no air valves on the radiators, the air being discharged with the return water.

The pipe sizes are so much smaller than those used in this country that at first glance they would seem to be entirely too small to be of any service, but the system has been in use in France and in Germany for something like twenty years, and seems to be constantly growing in favor.

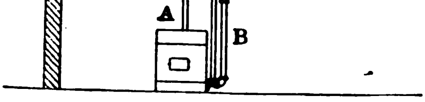


FIG. 204—PRINCIPLES UNDERLYING THE SYSTEM

Fig. 204 shows the simple principles underlying the system. A is the supply pipe from the steam dome of the boiler. B is the return end of the steam pipe, where it has made a circuit and re-enters the boiler. As this pipe pitches down from the boiler all the water of condensation in the pipe will be returned to the end of the line. The pipe C is the return pipe into which all the radiators drain. This pipe also enters the boiler below the water line and from the point where it drops to the boiler an air line is carried into a collecting tank and from the collecting tank a drain pipe runs to the boiler and an air pipe carries the air outside, as shown in Fig. 205.

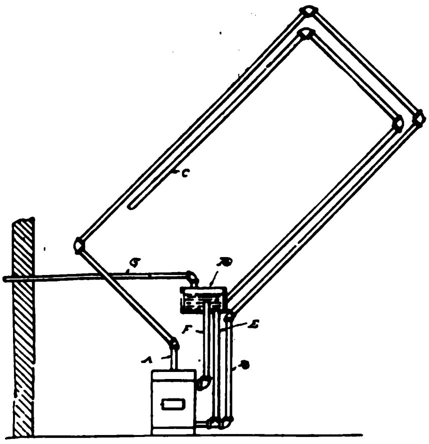


FIG. 205—STEAM HEATING IN EUROPE

In Fig. 205 A is the supply pipe, B the return of same to boiler, C the return main which carries the air and water of condensation, D the collecting tank, F the safety pipe, and G the air line.

The valve used on this system is a valve with two graduations. The first graduation, or adjustment, is set by the steamfitter who installs the work and is intended to admit no more steam than will be condensed by the radiator. When the valve is properly set and the normal pressure is on, which is usually about 1½ pounds, there will be no steam escape from the return end of the radiator.

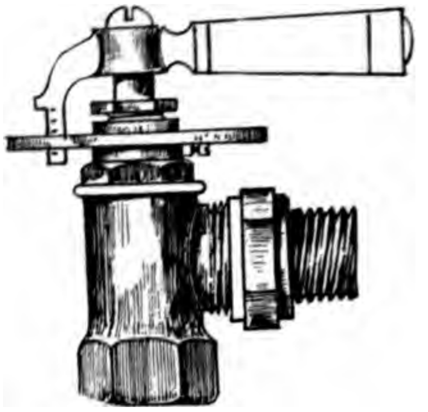


FIG. 206 A QUICK OPENING REGULATING VALVE

The second adjustment of the valve is made by the householder from time to time as it is desired to use certain portions of the radiator to meet the changes in outside temperature. The valve can be so adjusted that but two loops of the radiator are in service and later in the day, when four loops are necessary, the valve is opened a little wider.

Fig. 206 illustrates one of the quick-opening regulating valves in use on this two-pipe system. The first adjustment is effected by turning down the valve stem, which decreases the opening in valve. This is done by removing the handle, which is used as a key for operating the valve stem. After the adjustment is set for the maximum quantity of steam which shall pass into the radiator, the handle is put in place and fastened with a set screw. It is then impossible for the house owner to open the valve any wider than the adjustment made by the steamfitter. The valve can be set for less steam but not for more, and after the valve is once properly adjusted for a given sized radiator, excellent results are obtained by its use.

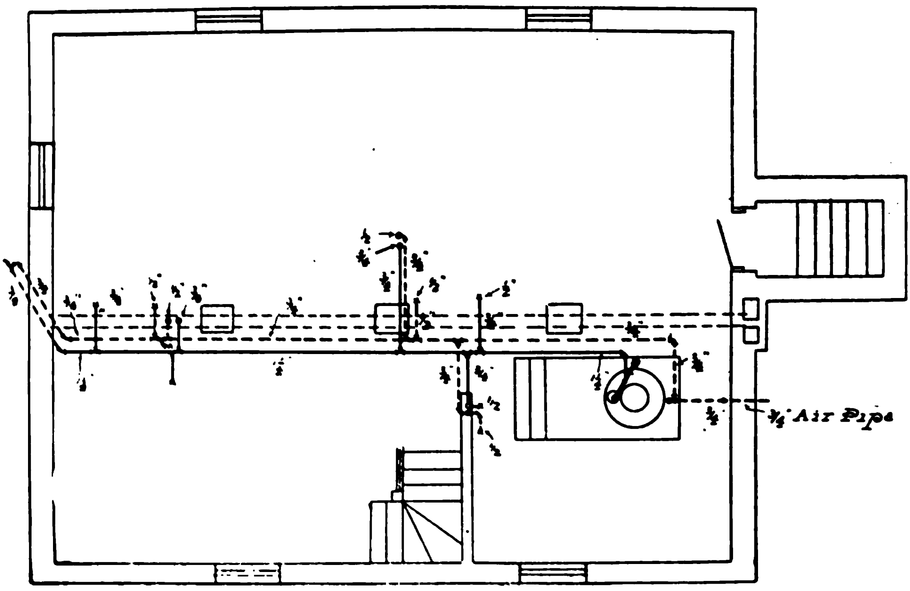


FIGURE 207 STEAM HEATING IN EUROPE—BASEMENT FLOOR PLAN

From this point of view the system described would seem to be much superior to any steam heating system in this country. But this system has its defects.

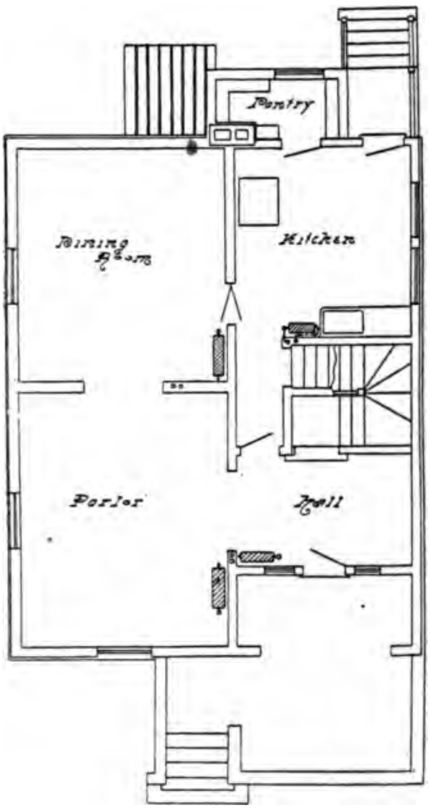


FIG. 208 FIRST FLOOR PLAN

Owing to the necessity of carrying a pressure on the steam lines and no pressure on the returns, the water will rise in the return pipe until a head is reached which will balance the initial pressure. If the pressure carried is 2 pounds then there must be a difference of about 4 feet between the water line of the boiler and the lowest part of the piping, and for this reason the engineers of Europe have been working to install the apparatus so that a pressure less than 2 pounds may be carried on the system. It is now generally conceded by the best engineers in France and Germany that 1½ pounds pressure is the minimum pressure which can be carried on this system, which necessitates a difference between the water line and the lowest point of the piping of about 3 feet. In many installations it is necessary to make a pit for the boiler, to get the necessary height in the basement above the water line.

The system described is frequently referred to as the "French" System, and at other times as the "German" system. As a matter of fact almost every engineer in Europe has his own peculiar method of installation. The principle may be the same in every case but each engineer strives to give the impress of his individuality to his work, both in design and execution.

In some installations the collecting tank is not used but the air pipe goes directly to the atmosphere and is left open at all times. In other installations a complex arrangement of tanks and condensing radiators is used, but each system is based on the principle of the regulating valve with pressure on the supply lines and no pressure on the returns.

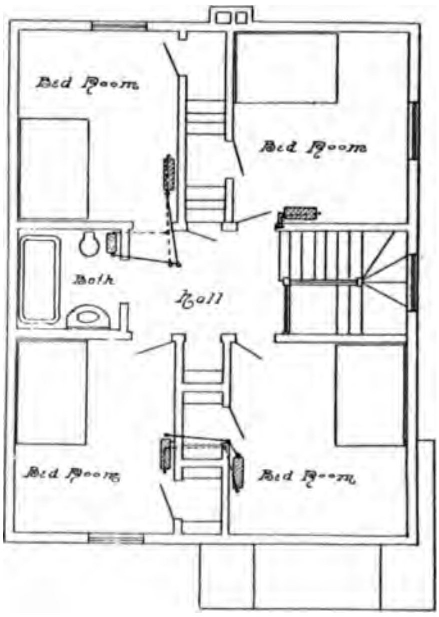


FIG. 209—SECOND FLOOR PLAN

The pipes used in this system are usually ½ inch to the radiator, with a ⅜-inch, and sometimes a ¼-inch return. It

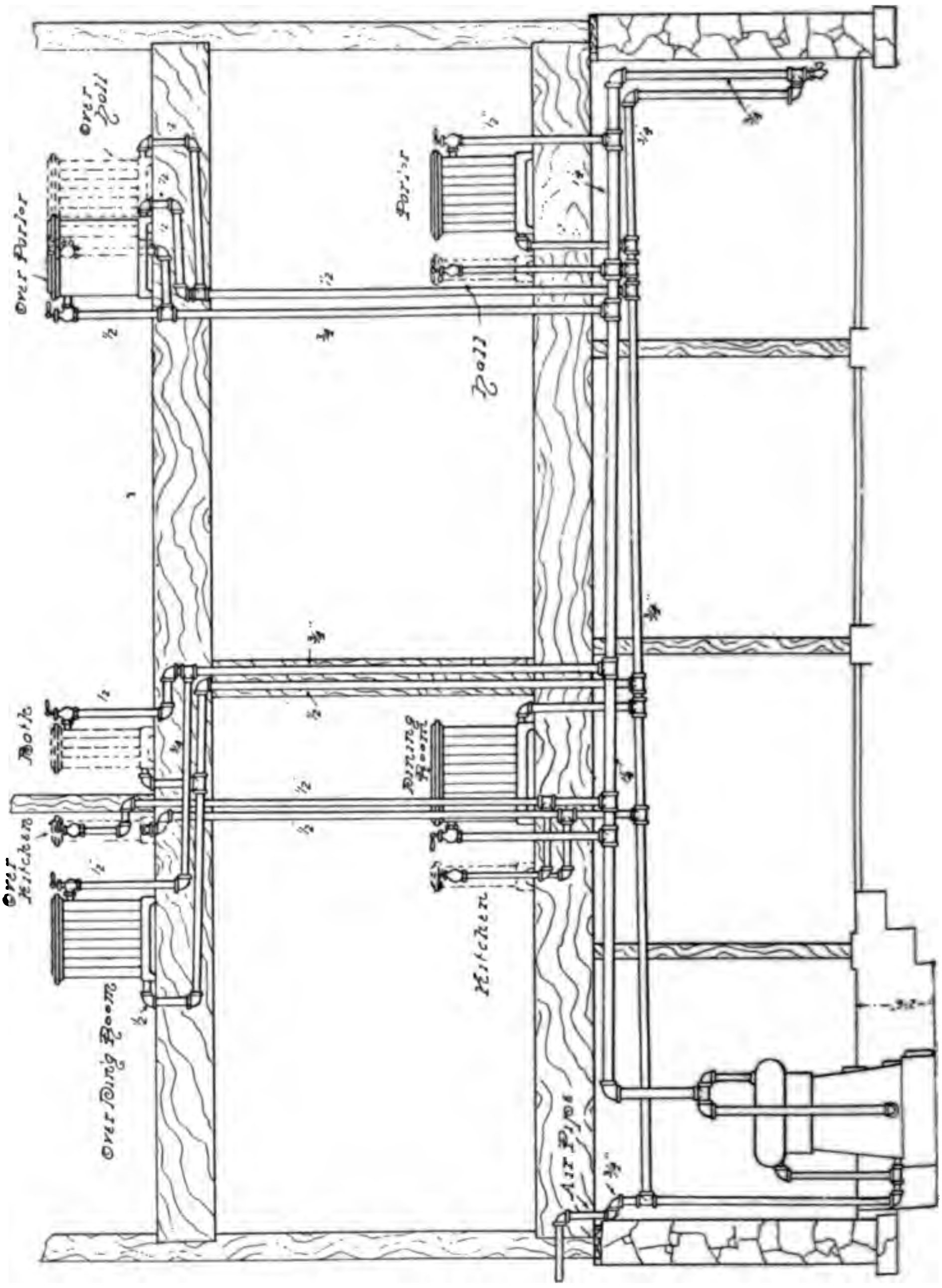


FIG. 210–ELEVATION SHOWING THE BOILER SETTING IN A PIT IN THE BASEMENT AND THE VARIOUS RADIATOR CONNECTIONS

t unusual to see a radiator contain-
00 square feet connected by a ½-inch
y and a ⅜-inch return.

many installations copper pipe is
as it can be easily bent, and the
nental fitter uses as few fittings as
ble, preferring to bend the pipe into
equired shape. This process would
nsidered rather slow in this country.
e claim having been made that this
m was of French or German origin,
the question being frequently asked
such a system was not in favor in
Jnited States, the late Mr. Frederic
r, in the "Engineering Review" of
mber and October, 1901, explains the
n of the system, and shows by patent
ings that he was the original in-
r. Mr. Tudor in his paper gives a
h of the condition of the heating
ess when he entered it in 1875 in
ollowing words:

hen I went into the business of heating
entilating, the art was at the lowest pos-
ebb. The extraordinary impetus given to
the triumvirate of genius, Walworth,
and Briggs, had come to naught through
ant of popular appreciation and the in-
able apathy and indifference of the ar-
ts. Ignorant of this fact then, and
witnessing the wretched state of the
inferred that there was an opening for
ering skill in devising better processes
were then in vogue. Influenced by this
by personal reasons, and especially by a
ence that I should succeed in a new and
ial field of activity, I decided to give
practice as civil engineer and take up
of sanitation. This was in 1875. The
ing ten years were years of incessant
and struggle against established houses
antiquated customs, against precedent,
ge and prejudice, during which period I
ated, developed and perfected most, if not
the modern systems of heating and ven-
n. In doing this I utilized established
ples for all they were worth. I invented
pplied new ones; and the merit of my
nations rested chiefly in the fact that
were harmoniously related, practical and
eable. I set before myself the problem,
y what was to be accomplished; then I
as a matter of engineering, processes
would produce the result required. The
ble condition of the trade from an en-
ing standpoint was due to the ignorance
ny of those in whose hands it was at that
they neither knew what they wanted to
plish, nor had they the knowledge and
to solve a problem when it was sub-
to them.

"The complete revolution in this art that has taken place in the last twenty-five years is to be ascribed to me, and was set on foot at that time. This is all a matter of record, and I do not care to go into it further in this place, except so far as it will throw light upon the questions of Mr. Debesson. The only part of this development that I had no hand in at all is the so-called American system of low-pressure gravity steam-heating. This had already been brought to perfection by Massachusetts and, chiefly, Boston mechanics. It must be admitted, as Professor Carpenter and other members of the Society of Heating Engineers claimed, that it is a perfect working system, extremely simple in its construction and operation.

"But these are virtues that can be appreciated by the engineer only; he alone understands what has been accomplished by the system, and how, through it, a perfect and noiseless circulation has been made possible. The users of the system know nothing about this, and they ask how it is that engineering skill is unable to do away with the coarse pipes and fittings that are in the way of furniture, and besides occupying valuable space, overheat their rooms even when the radiators are shut off; nor why the heat of the latter cannat be graduated to the requirements, and controlled in a simple way. Why can one not turn on a little heat, just as one turns on gas or water, by a single, easily manipulated valve? Why should it be necessary to send for a man or stout boy to operate the two factory-like implements that control the heat, whenever it is necessary to change the heat of the room? The whole steam-heating outfit is adapted more appropriately to factories than dwellings, and seems to be intended for work-

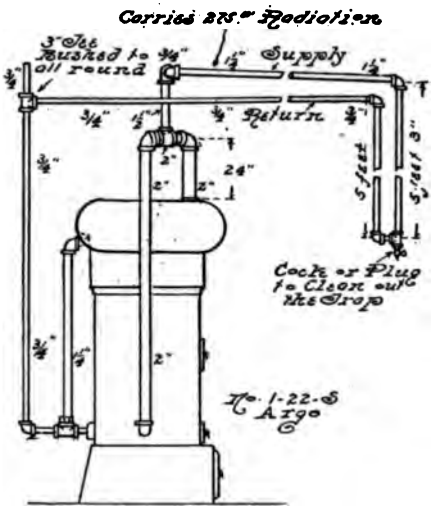


FIG. 211—BOILER CONNECTION

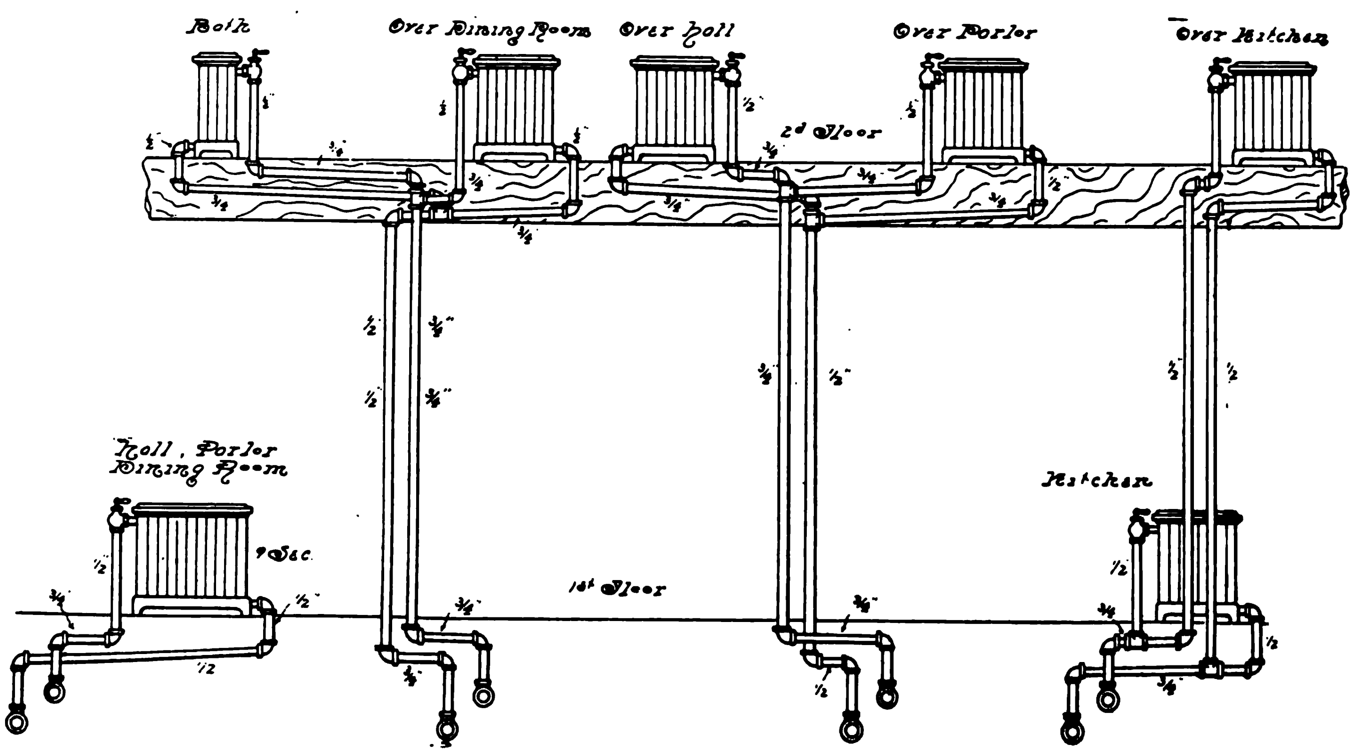


FIGURE 212—STEAM HEATING IN EUROPE—SECTIONAL VIEW SHOWING THE RISERS

ing mechanics to handle. The comfort and convenience of the average citizen, and especially of the average woman, have not been considered by steam-heating engineers.

"All these objections were perfectly plain to me when I entered into the business of heating, but previous to 1880 I had all that I could attend to in improving the art of ventilation in connection with heating, and I had very little to do with heating by direct radiation. After all its advantages have been summed up, in the important respects of health and comfort, it is seen to be a vile system, and it did not interest me except to imagine how it could be improved."

Mr. Tudor then goes on to explain the various systems which he had patented and how a restricted nipple into a radiator led to the invention of the regulating supply valve.

He also states that it is his belief that the reason the system was not adopted in the United States was due to the fact that he controlled the patents and no one was willing to pay him any royalty, but instead did everything in their power to discourage the use of any device which he had patented.

Figs. 207, 208 and 209 are the basement, first floor and second floor plans of a building equipped with the French or Tudor system of steam heating.

Fig. 210 is an elevation showing the boiler setting in a pit in the basement, and the various radiator connections.

Fig. 211 is a view of the method of connecting the piping to the boiler.

CHAPTER XLVIII.

HEATING COUNTRY STORES.

THE heating trade located in the smaller towns are often asked to figure the cost of heating, with steam or water, a dry-goods, grocery or drug store, and when the radiation is computed by the same rule which they have applied successfully to house heating, they find the price so high as to be prohibitive, and the question is often raised—what rule should be used for computing the radiation required in stores filled with merchandise?

Many of the rules in common use are not based on sound principles, that is, the factor for glass is frequently too high and the factor for walls too low. So long, however. as the proportions do not vary greatly, such a rule will work out fairly well. It is better, however, to have a rule that apportions to each material, be it glass or wall, the amount of radiation necessary to furnish the heat lost by that material.

Where there is a temperature difference of 70 degrees, that is, 70 degrees inside the room, and zero outside, and where the windows consist of single glass, 1 square foot of radiation to 3 square feet of glass will offset the cooling power of the glass where the radiators are at a temperature of 217 degrees, which is equivalent to 2 pounds initial pressure in low-pressure steam heating. For the exposed wall 1 square foot of radiation should be apportioned to 12 square feet of wall, and for the cubic contents 1 square foot of radiation to 200 cubic feet, which allows for one change of air per hour. For water heating, with a mean temperature in the radiators of 170 degrees, add 60 per cent. to the amount obtained by the above factors.

Where a store is located in a block it is always understood that the side walls do not lose heat, as it is assumed that the stores on either side are warmed. When the building is detached it is then customary to figure for a loss of heat in the side walls, and here is where the average steam fitter is away off in his calculations. The side walls of a merchandise store are generally shelved and filled with goods of some kind. In a dry-goods store there is practically no loss

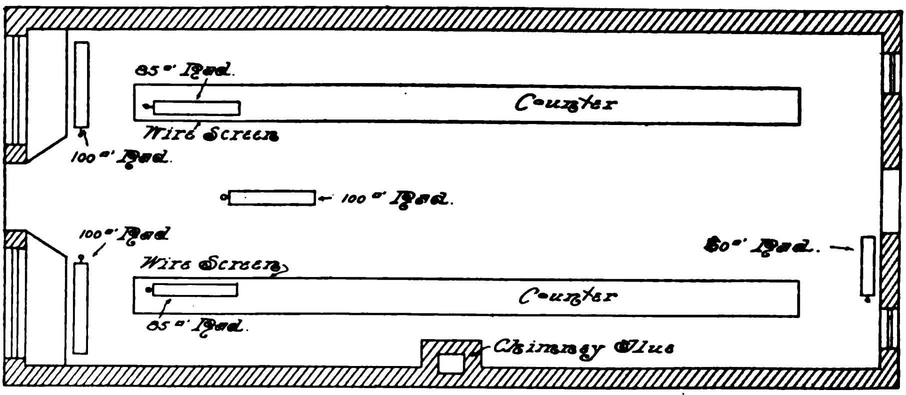


FIGURE 213 GENERAL STORE SHOWING QUANTITY OF RADIATION

of heat through the side walls and very little in stores of any kind where there is shelving with goods. It is safe, therefore, to disregard all walls that are shelved and filled with goods and compute the radiation by the exposed glass and exposed wall where there is no shelving, plus the radiation necessary to warm the cubic contents once per hour.

In Fig. 213 we show a floor plan of a store 40 feet wide, 100 feet long and 14 feet height of ceiling. In this store there are 620 square feet of glass, 500 square feet of exposed wall not protected by shelving, and 2,800 square feet of exposed wall which is shelved and filled with goods. The disposition of the radiation is shown in the sketch. One radiator is placed next to each front window; one radiator in the center of the floor, and one radiator under each counter. In front of the radiators which set under the counters is placed a screen, which permits the air to flow into the store, acting as a direct-indirect radiator, as it will take the cold air from the floor and deliver it into the center of the store at a higher point.

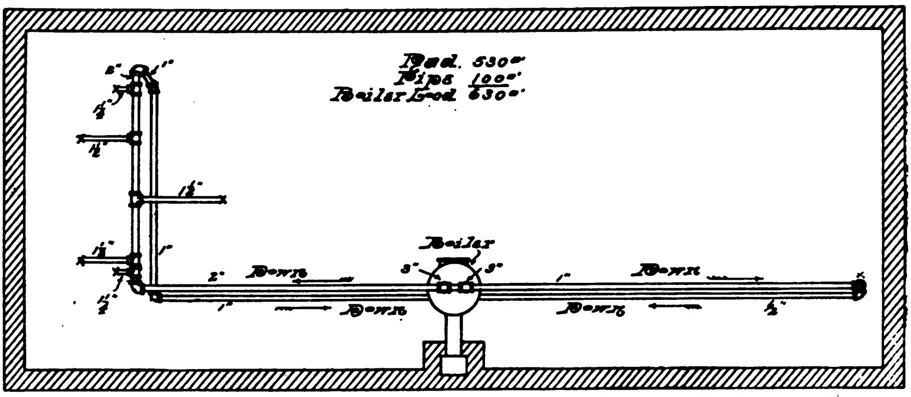


FIGURE 214—BASEMENT AND PIPE PLAN OF GENERAL STORE

The air space in this store is 56,000 cubic feet, which we divide by 200, giving 280 square feet of radiation. The 620 feet of glass we divide by 3, giving 206 square feet of radiation, and the end wall we divide by 12, giving 44 square feet of radiation. We ignore the side walls and find there will be required 530 square feet of steam radiation. This quantity of radiation, installed as shown by the piping plans in Figs. 213 and 214, would cost the owner about $375.

As against this, figuring in the usual way, there would be required for the cubic contents 280 square feet, for the glass, 1 to 2, 310 square feet, and for the end and side walls, 1 to 20, 165 square feet, a total of 755 square feet. A fair price for this quantity would be $550.

If water heating were installed in place of steam and were figured on the same basis as above, there would be required 1,200 square feet, and the cost would be about $800.

In Fig. 215 we show floor plan of a store 20 feet x 80 feet x 12-foot ceiling. This gives 19,200 cubic feet of air, which we divide by 200, giving 96 square feet of radiation. There are 280 square feet of glass, which we divide by 3, giving 93 square feet of radiation. There are 220 square feet of exposed wall at the end of the store, which is not covered by shelving, and this we divide by 12, which gives 19 square feet of radiation, a total of 208 square feet. The building is detached, but the side walls being shelved and filled with goods, we disregard them.

This quantity of radiation, with a small steam boiler capable of carrying it and maintaining fire for 8 hours, could be installed for about $180. Figured by the ordinary house rule would bring the radiation up to 340 square feet, which would cost about $220 to install, or about $400 for water heating.

In Fig. 216 we show floor plans of a store 18 feet x 50 feet with 10-foot ceiling, containing 9,000 cubic feet of space. There are 200 square feet of exposed glass and 160 square feet of exposed end wall. The side walls have 1,000 square feet, but are shelved and filled with goods and will be disregarded as a cooling factor. The cubic contents we divide as above by 200, giving 45 square feet of radiation; the glass by 3, giving 66 square feet, and the end wall by 12, giving 13 square feet, a total of 124 square feet. This could be installed for about $135.

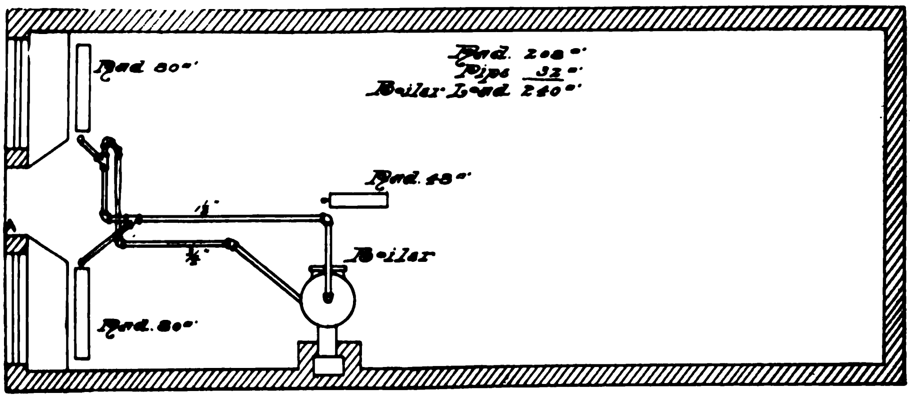


FIGURE 215 -PIPING IN BASEMENT SHOWN ON FIRST FLOOR PLAN

Figuring by the usual method would give 210 square feet of radiation, which would cost to install about $180 for steam or $320 for water.

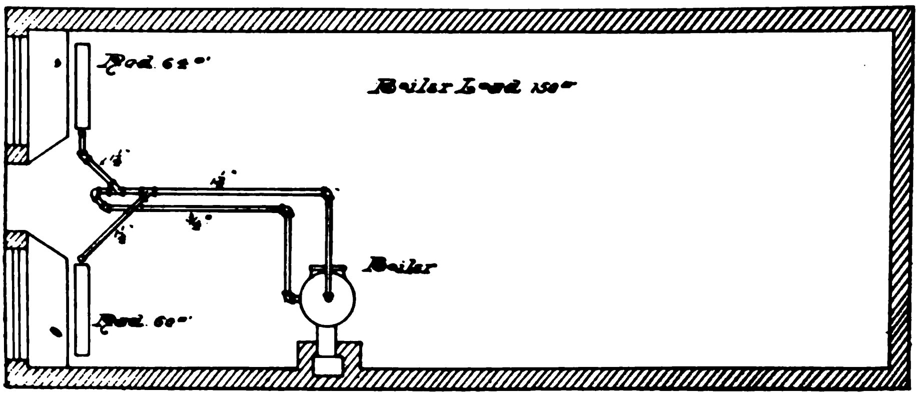


FIGURE 216 -FLOOR PLAN OF A STORE 18x50 FEET

There are thousands of stores throughout the country that would be glad to dispense with the smoke and dirt incident to heating with stoves and install radiation, if the price were not, in their eyes, prohibitive. In many cases when the local fitter is asked to submit a price for heating the store he advises the owner to install a water heating apparatus, for the reason that it will maintain heat in the store through the night, and the assertion is frequently made that if steam is installed the radiators will become cold during the night and in the morning the store will be too cold for comfort.

This is where the steam fitter makes a great mistake. It is just as easy to maintain temperature during the night in steam radiation as it is to maintain heat in water radiation. It is all a question of having a boiler with sufficient fuel capacity to maintain steam a given number of hours. If the store is vacant from 10 o'clock at night until 6 o'clock in the morning, the boiler must have sufficient fuel capacity to maintain steam for eight hours; but if the store is closed at 6 o'clock in the evening and opened at 8 o'clock the next morning, the boiler must have fuel capacity sufficient to maintain steam for fourteen hours, or nearly double the capacity required for the eight-hour run. It is not entirely a question of a boiler's capacity to carry a given amount of radiation, but rather the boiler's capacity to carry a given amount of radiation for a given time.

Another means of keeping the cost down is to use smaller piping than is the custom, and this can always be done where the pipe connections to the boiler are of large area. For instance, it is perfectly feasible to carry 600 or 700 feet of radiation on a 2-inch pipe, but if the steam left the boiler through one 2-inch pipe to supply 600 feet of radiation the velocity would be so high as to carry the water out of the boiler and into the radiation. Where a 2-inch pipe is used to carry 600 feet of radiation, there should be two 3-inch risers out of the steam dome of the boiler to which the 2-inch pipe must be connected. This will give a velocity of 40 feet per second in the 2-inch pipe and an initial velocity leaving the boiler through the two 3-inch pipes of 9.5 feet per second, which will insure dry steam in the pipe lines.

CHAPTER XLIX.

HEATING FURNITURE STORES.

PROGRESS" writes as follows: "I have recently installed two small hot-water plants according to your ideas of pipe sizes, using 1½-inch and 1¼-inch pipe where I had formerly been using 2-inch and even larger sizes, and was both surprised and delighted to find the circulation more rapid and a more even temperature in the radiation than I had ever before experienced in my work. If these jobs work as well in the winter as they do on trial there will never be any further question in my mind regarding your pipe sizes. I have another job to do which is a little different from anything I have ever tried and I would like to ask your advice in regard to the layout of the piping.

The building is a three-story brick one, 100 feet long, and 20 feet wide. It is to be used as a furniture store. There is a basement under the entire building. On the first floor, two sides of the building are protected by adjoining buildings; that is, they are party walls. On the second floor, the rear 40 feet on both sides of the store are exposed. The third floor extends 60 feet back from the front of the building, making a space 60 x 20. On top of these three floors is a flat roof composed of tar and gravel. The same kind of a roof covers the rear part of the second story. There is a small space between the roof and ceiling, probably about 12 inches in front running to nothing at the rear.

"The heights of the ceilings are: First floor 12 feet, second floor 10 feet, and third floor 10 feet.

"The proprietor of this store wants me to heat it with hot water, as he thinks it will not be as hard on the furniture as steam heat.

"The temperature of the first and second floors is to be 70 degrees, but the third floor is to be about 40 degrees, or just enough to keep water from freezing.

"I enclose herewith floor plans of the building which show the exposed walls and glass, and would be very glad to have your views in regard to the lay-out of the radiation and piping."

The floor plans of the furniture store referred to by our correspondent have been re-drawn, piping plans have been inserted, and the layout is fully illustrated in Figs. 217, 218, 219, 220 and 221.

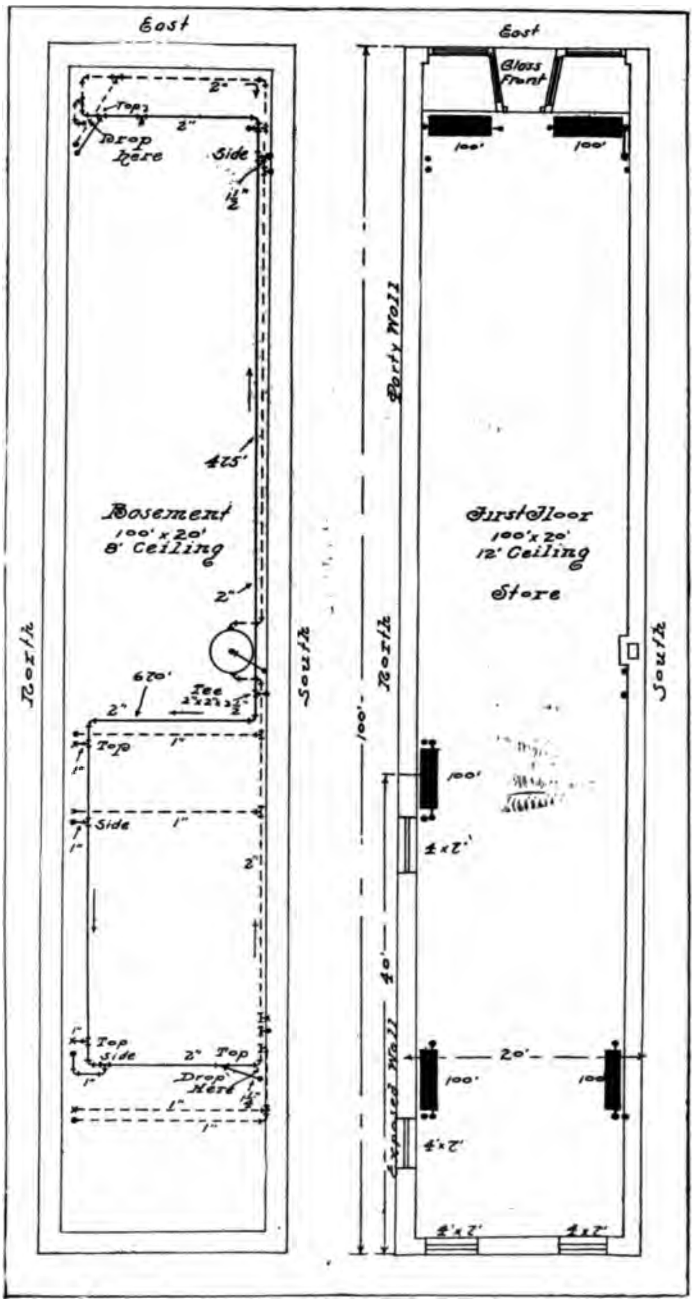
On the first floor, we assume that the air will change once per hour through the frequent opening of the doors, and that we must, therefore, have sufficient heat to raise the temperature of the cubic contents from zero to 70 degrees once per hour. Of course, it is understood that in figuring for heating apparatus in this climate, we must make allowance for the coldest weather, and it is usual in the middle northern States, to call the coldest weather zero. It may be colder than that for a few hours for a few days during the season, but no one will complain if at that time, it is not possible to get the temperature to 70 degrees, though as a rule it is just as easy to warm a building when it is ten degrees below zero as when it is zero, because with the lower temperature, there is not likely to be any wind.

We find on figuring the first floor, that there are:

24,000 cu. ft. of air space,
352 sq. ft. of window openings,
720 sq. ft. of exposed walls.

We figure this on a low-pressure steam basis; that is, steam at 2 pounds initial pressure, and add to the quantities obtained for steam—60 per cent., which will give the corresponding quantities for water radiation, when the mean temperature of the radiation is maintained at 170 degrees.

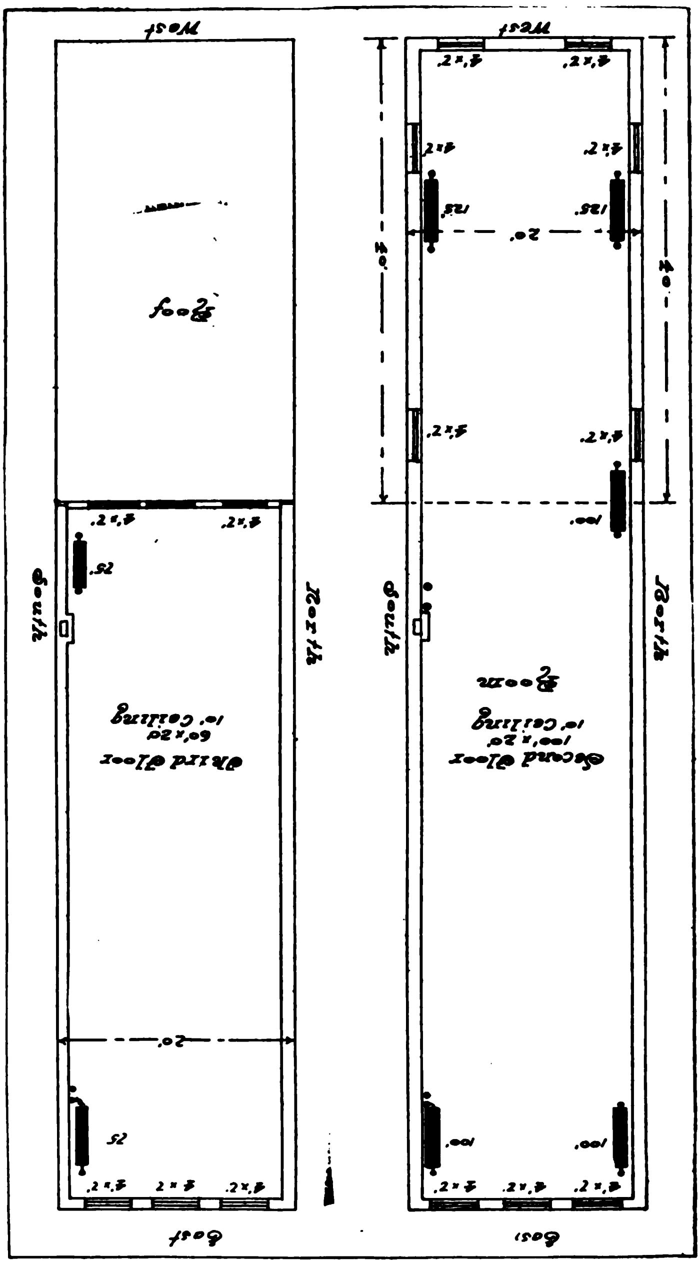
To raise the temperature of 1 cubic foot of air from zero to 70 degrees Faht., requires 1.4 B. T. U., and as steam radiation under the conditions named will emit 240 B. T. U. per square foot per hour, we multiply the cubic feet by 1.4 and divide the product by 240, which shows that the quantity of radiation re quired to warm the air is 140 square feet. Each square foot of window glass, with zero weather outside and 70 degrees inside, will require 72 B. T. U. to replace the loss of heat. We, therefore, multiply the glass by 72, dividing the product by 240, and find that 105 square feet of radiation will be required to offset the loss



FIGS. 217 AND 218—PLANS OF BASEMENT AND FIRST FLOOR OF FURNITURE BUILDING

of heat by the glass thus exposed.

The exposed walls at the two ends of the building require 22 B. T. U. per square foot per hour to replace the loss of heat by transmission through the walls, and we, therefore, multiply the exposed wall by 22, and divide the product by 240, which gives 66 square feet required to offset the loss of heat through the exposed walls.



FIGS. 219 AND 220—PLANS OF SECOND AND THIRD FLOORS OF FURNITURE BUILDING

This gives a total of 311 square feet which will be required to warm the first floor, if steam radiation be employed. Adding 60 per cent. to this, for water, gives us approximately 500 square feet, and we have, therefore, placed on the first floor 5 radiators, each containing 100 square feet.

On the second floor, as there are no outside doors and no special ventilation, we assume that the air changes not more than once in two hours, so that only half the cubic contents of the room must be warmed per hour. The B. T. U. multiplier for one change of air per hour being 1.4, it follows that the multiplier for one change in two hours must be 0.7.

The cubic contents of the second floor are 20,000 feet, multiplied by 0.7, and the product divided by 240, gives 59 square feet. There are 250 square feet of glass; which multiplied by 72, and divided by 240, gives 75 square feet. There are 1,087 square feet of exposed walls, which multiplied by 22 and divided by 240, gives 100 square feet. There are 800 square feet of exposed roof which in this case we will treat the same as though it were a side wall. Multiplying it by 22, and dividing by 240, gives 73 square feet. We have now provided for every source of heat loss except the ceiling of the front part of the store, which is 60 x 12, and contains 1,200 square feet.

As the rooms above the second floor are to be maintained at a temperature of 40 degrees, there will be a loss of heat through the ceiling of the second floor. We compute this loss at 10 B. T. U. per square foot per hour. Multiplying the 1,200 square feet by 10, and dividing the product by 240 gives 50 square feet, making a total of 357 square feet required for steam radiation. Adding 60 per cent. to this gives a total of 570 square feet required for water, and this is divided into five radiators, the larger quantity being placed in the rear of the store where the loss of heat will be greatest.

On the third floor we have 12,000 cubic feet of air. We figure that the air will change once in two hours, and to raise the temperature of 12,000 cubic feet of air from zero to 40 degrees in two hours requires 0.3 B. T. U. We, therefore, multiply 12,000 by 0.3 and divide by 240, which gives 45 square feet. There are 140 feet of glass which will require 32 B. T. U. per square foot, and 140 multiplied by 32, and divided by 240 gives 19 square feet. There are 260 feet of exposed wall and 1,200 feet of exposed roof. This 1,460 feet we multiply by 10 and divide by 240, which gives 60 square feet, or a total of 94 square feet of steam radiation required to maintain a temperature of 40 degrees in the third floor, when the weather outside is at zero. To this we add 60 per cent. and find the requirements for water radiation to be 150 square feet. This is divided into two radiators of 75 feet each, which are placed in the southeast and southwest corners of the room. The reason for placing these radiatirs on the south wall, rather than on the north, is because the northeast and northwest winds will drive the air against the south wall, so that the radiators placed in that position will be more efficient than if they were placed on the north wall, where they would only be subject to the wind pressure from the southeast and southwest winds.

It is understood, of course, that the side walls of these three floors are protected by party walls, there being warm buildings on either side.

The total radiation is 1,220 square feet. The piping which will probably be exposed, will give off some heat in addition to the radiation, but as there is only a small quantity of it, it is not necessary to take it into account.

To carry this quantity of radiation, a good standard boiler of 1,500 square feet capacity should be selected. This boiler will carry the radiation at its maximum power for eight hours, but in moderate and mild weather, will run from ten to fifteen hours without attention.

If the proprietors of the store insist upon having a boiler that will run twelve hours without attention in zero weather, and keep the radiation at a mean temperature of 170 degrees, a boiler of 2,250 feet capacity must be provided in order to furnish the necessary fuel capacity.

Fig. 217 shows the piping plans in the basement. The solid lines represent the flow pipes, which pitch down from the boiler. The dotted lines represent the return pipes which pitch down toward the boiler.

As the sizes are all marked on the plan, it is not necessary to recite in detail every fitting.

The branches are marked on the plan, when they should be connected to the top of the main, and when to the side. These branches which terminate in the first floor radiators are marked with a cross. Those which terminate on the upper floors are marked with a circle. The piping all pitches down in the direction indicated by the arrows. Each and every radiator, irrespective of its size, is connected with a 1-inch valve.

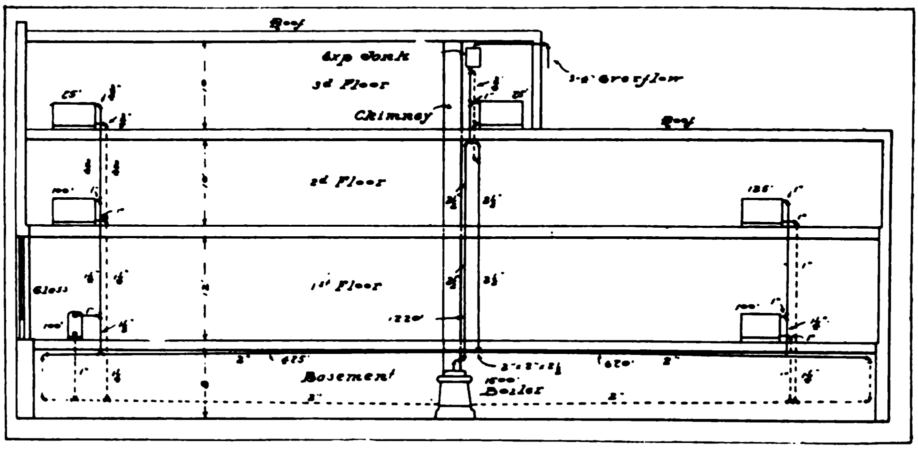


FIG. 221—SECTION OF FURNITURE STORE SHOWING BASEMENT 1ST, 2ND AND 3RD FLOORS

The two radiators in the front of the store on the first floor, may be low heights, or what is termed window radiation, if desirable. All the other radiators throughout the building would better be standard height, which is really 38 inches. The three radiators in the front of the building on the first, second and third floors are to be connected, as shown in Fig. 221; that is, a branch from the rising line is connected into the top of each radiator. In this way only the radiator on the third floor will require an air valve, others venting through risers.

The returns from the second and third floors are connected together and drop directly into the main return from the radiator on the first floor to the main return. In this way, there will be no danger of the return water from one radiator entering that of another.

The radiators on the north side on the first and second floors are connected in the same manner, while those on the south side are shown with separate connections. This is done to give variety of piping more than anything else, because by this way, you can observe whether there is any difference in the two styles of connection. If all your connections are made exactly alike you will never know whether or not there is a better way. The probability is that you will not be able to detect any difference between the working of the two lines, but there are many heating contractors who will say that when two radiators, one above the other, are connected to the same line of piping, the lowest radiator will not heat, unless some special form of fitting is used, which will direct or deflect the warm water into the radiator, overlooking the fact that the weight of the water in the return column will induce the lighter water to follow it.

One advantage of connecting the radiators, as shown in Fig. 221, is the facility with which radiators may be connected, as the connecting points are both at the same end. The valve may be put on the return pipe, if desired.

It is expected that the heating contractor will not attempt to run a rigid connection between the rising line and the radiator, but that the risers will be set close to the wall, so that the connecting points may be taken off the side of the riser on a swing joint; or a branch may be taken from the riser at a point above the radiator and dropped down. Either manner will obviate rigid connections. Another good point in this kind of connection is the elimination of air valves. The less air valves that a heating apparatus has, the better, whether it be steam or water, always provided that the air can be taken off in some better manner.

Reverting again to Fig. 221, it will be seen that one 2½-inch main is connected to the boiler and after swinging to one side of the chimney, is carried up to the ceiling of the second floor. At that point a 2½ x ¾ x 2½-inch tee may be used, from which a ¾-inch pipe is run to the expansion tank and also connected to the radiator on the third floor. A return pipe is run from below the expansion tank and connected into the 2½-inch flow pipe, at a point 12 or 15 inches below the ceiling. When the 2½-inch flow pipe returns to the basement, it is fitted with a 2 x 2 x 2½-inch tee and from that point the two flow pipes are connected, as is clearly shown in the sectional view, Fig. 221, and in the basement plan, Fig. 217.

Twin ells and special fittings with tongues in them need not be used in this apparatus, as the circulation will be very rapid, and it will be impossible to prevent the radiators from heating unless they are shut off with a tight valve. If the valves used on the radiators in this job have a 1-16 hole drilled through them, the radiator will still heat, because of the rapid circulation of the water through the piping.

In regard to pipe sizes advocated by the writer, there is, of course, no law in the country compelling anybody to use them, and it is a matter of supreme indifference to the writer whether they are used or whether the current sizes are continued. The only difference is this: Any system that can be introduced which will cheapen the first cost of steam or water heating apparatus will enlarge the field of operation, and the writer knows by experience extending over a number of years that the current pipe sizes in both steam and water heating may be cut in two, with good results. Until some prominent man, company, or society takes this matter up and makes actual experiments, where the operation of the apparatus can be seen in glass tubes, very little progress will be made, because at present the trade has no scientific data as a basis for determining pipe sizes. One man says that if the pipe is small, there will be so much frictional resistance that the water will enter the radiators through the return.

Assuming that it is common practice to use a 3-inch main for 900 feet of radiation, the assumption is that if a 2-inch main is used, the frictional resistance will be so great that the loss of pressure in the return lines will cause the water to leave the boiler and flood the radiation. Now, the question arises, why will a 2-inch pipe whose internal circumference is 6.4 inches, have a greater skin resistance than the 3-inch pipe whose internal circumference is 9.6 inches? Of course, the answer will be that the increased velocity in the 2-inch pipe will create friction. Well, suppose it does, what will be the net result?

The writer's idea is that before laying down laws for others to work by, the law giver should take the trouble to install heating apparatus with varying pipe sizes and determine by occular dempipe lines. One writer asserts that by produring a vacuum in the expansion tank of a water heating apparatus, the velocity of water is increased, and the heating effect is greater, which is equivalent to saying that a pound of coal will do more work in a given set of conditions if means are employed to produce a partial vacuum in the tank. Now, if this be true, why not attach a vacuum pump to the expansion tank and with a few strokes of the pump handle, produce a vacuum which will furnish sufficient heat in the mild weather of spring and fall, without using any fuel?

Another says that by the application of pressure on the water in a water heating apparatus, the circulation and heating effect are increased. According to this, there must be some circulation and some heat produced by the pressure, and if so why not use the city water pressure or a pump to do the heating in mild weather?

Another says that by enlarging the piping in a certain job, 50 per cent. of the fuel was saved; and still another, by the use of long sweep fittings, and 45-degree ells, 50 per cent. was saved in the fuel consumption.

Thoughtless statements of this kind do the heating business more harm than good, because such results are a physical impossibility.

A compilation of pipe sizes used by every fitter of fair experience in the United States might be interesting, but not very instructive, because they will be found to be very much alike. If there is a fitter here and there who is using smaller sizes than his competitors, he will be very careful not to say anything about it, and if he is asked for the pipe sizes used in his practise, will send in a list to correspond with the majority of lists now published in the various text books and catalogs.

CHAPTER L.

UNIQUE METHOD OF INSTALLING WATER HEATING APPARATUS.

IN describing the different methods of steam and water heating apparatus, we sometimes feel that we are wasting time and space in describing parts of the apparatus which are well known to everyone at all familiar with either plumbing or steam fitting, but a few weeks ago we discovered a job which was supposed to be a hot water heating apparatus, that has changed our views entirely on the subject, and we now believe that articles of this kind cannot be to elementary, because there is a constant supply of new men entering the field, many of whom have had no experience whatever in designing or installing heating apparatus.

The apparatus referred to was not found in some remote country district, as might be supposed, but within thirty minutes' ride of New York's city hall.

Fig. 222 is a plan of the boiler and piping. Fig. 223 shows the boiler with the expansion tank connected to same, and Fig. 224 shows a line of radiators on the first, second and third floors, and the manner in which they are connected.

Starting at the boiler, Fig. 223, it will be noticed that the expansion tank is connected to the boiler. This would not do so much harm if it were not that an air pocket is formed between the top of the tank and the top of the boiler.

The piping is not so very much out of the way, but might be improved upon. For example, a 3-inch line is run from the boiler to carry 435 feet, which is entirely too large, 2½-inch pipe being ample.

On one end of the run the pipe was reduced with reducing couplings, one of the worst possible things that could have

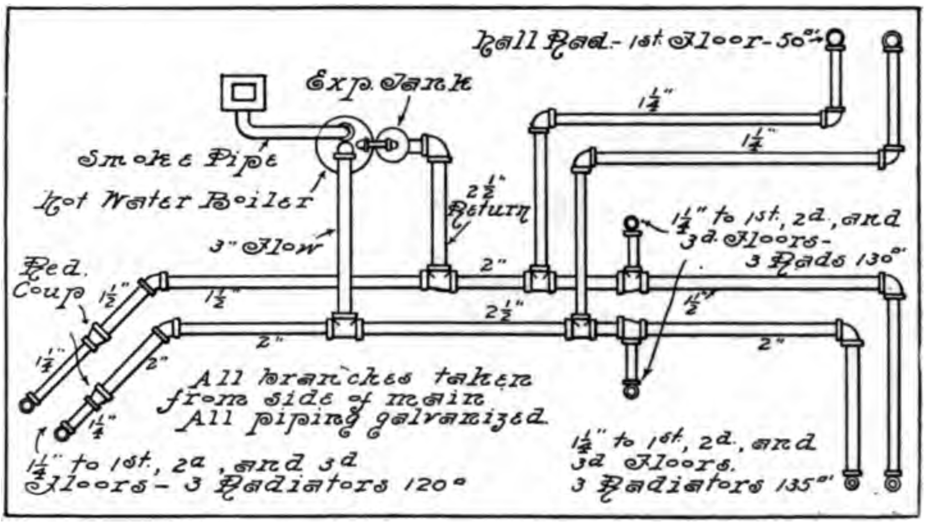

Hall Rad.- 1st Floor-50°
Exp. Tank
Smoke Pipe
Hot Water Boiler
3" Flow
2½" Return
1¼"
1¼"
1¼" to 1st, 2d., and 3d. Floors- 3 Rads 130°
Red. Coup
1½"
1½"
2"
2½"
1½"
2"
1¼"
2"
2"
1¼"
All branches taken from side of main
All piping galvanized
1¼" to 1st, 2d, and 3d Floors - 3 Radiators 120°
1¼" to 1st, 2d., and 3d Floors. 3 Radiators 135°

FIG. 222—HEATING JOB FOUND IN NEW YORK. PLAN OF THE BOILER AND PIPING

been done under the circumstances. The return main is run a size less than the flow pipe, but there is no harm in this because the flow pipe was larger than necessary.

Turning to Fig. 224, it will be noticed that the risers are the same size from top to bottom. There is no particular harm in this either, because the radiators will heat when connected up in this way if the return riser is properly connected, so that the circulation will be free. Of course it would be better to reduce the sizes of pipe on each floor.

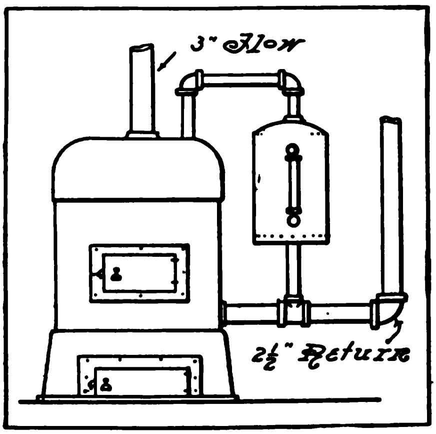


FIG. 223—A UNIQUE WATER HEATING APPARATUS

The unique feature in regard to the risers is an air cushion which was placed on the top of each line of risers. This certainly is a novel method of installing water heating apparatus. There were no valves on the radiators, because this air cushion was supposed to take care of all the air from the entire heating apparatus.

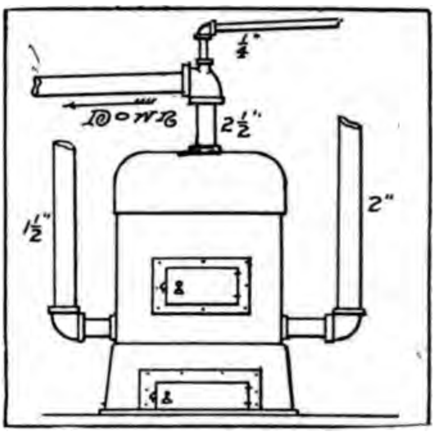


FIG. 226—SHOWING CONNECTION TO BOILER

In Figs, 225, 226 and 227 we show the proper method of installing this apparatus.

In Fig. 225, which is a plan of the job, the main flow pipe from the boiler is 2½ inches. From the top of the riser out of the dome of the boiler an air line

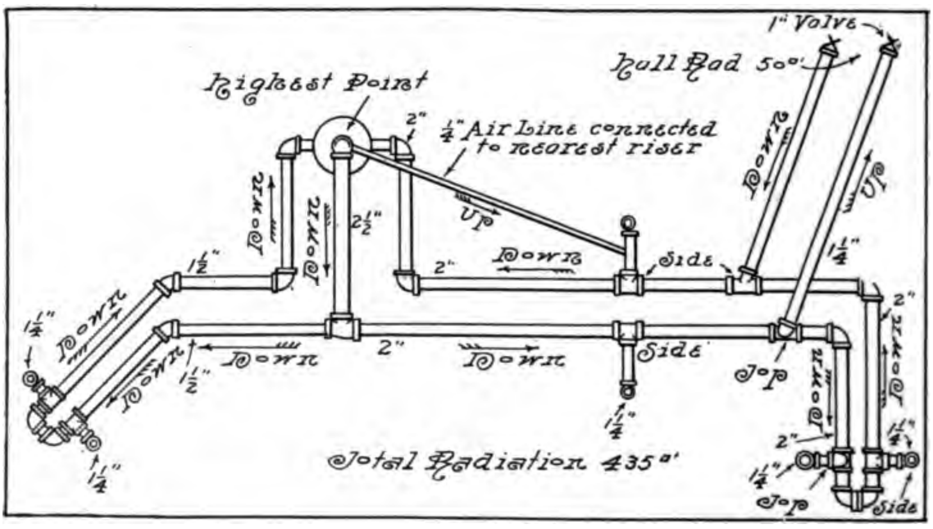


FIG. 225—PLAN OF PIPING AND PROPER METHOD OF INSTALLING THE APPARATUS

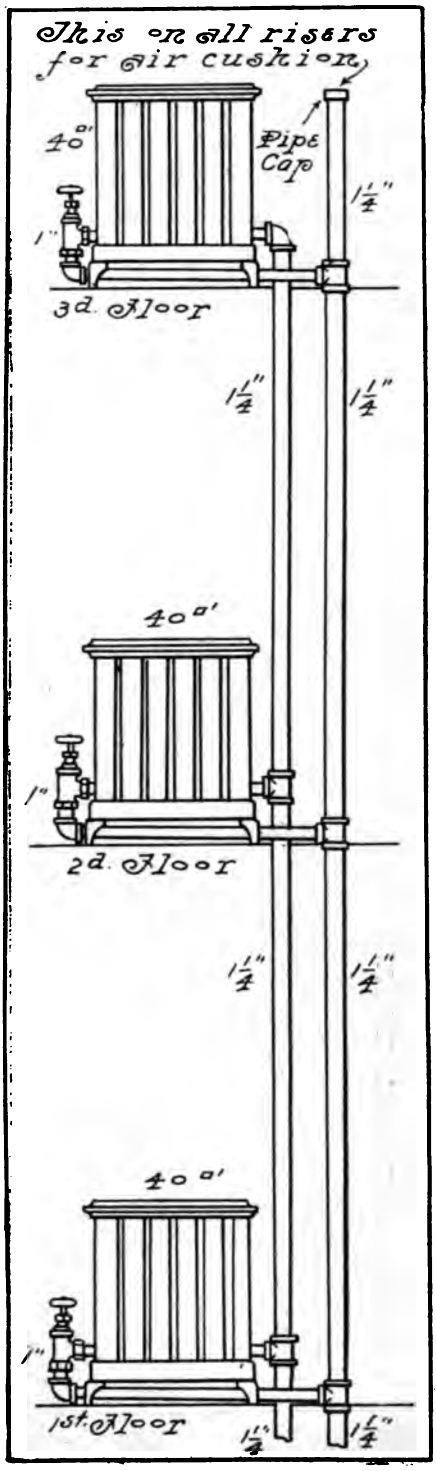


FIG. 224—SHOWING METHOD OF CONNECTING RADIATORS FOR RISERS

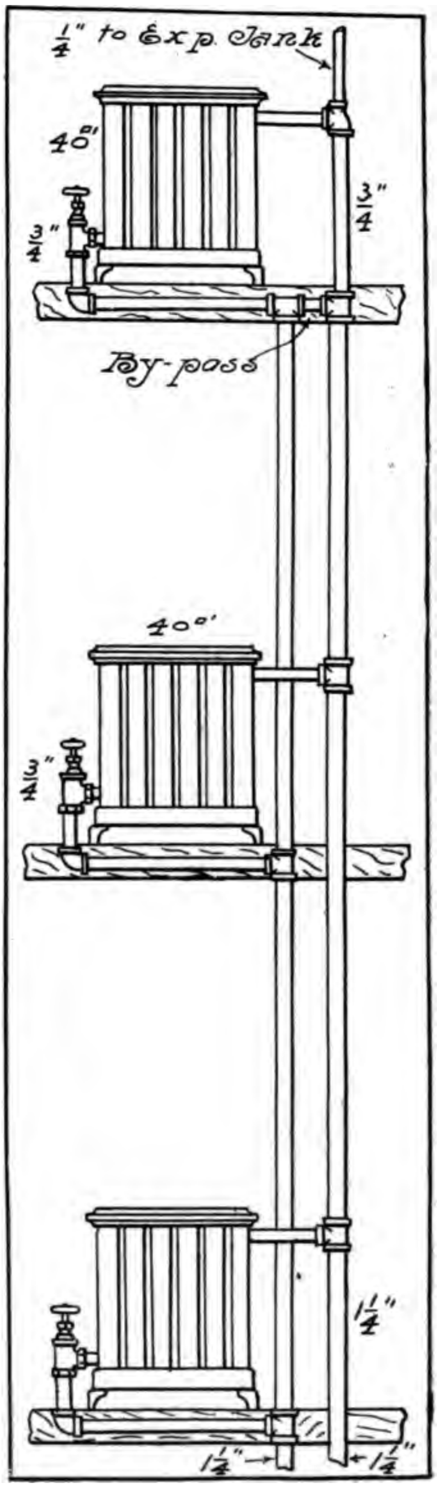


FIG. 227—RISERS TO 1ST, 2D AND 3RD FLOORS

is run and connected to the nearest riser. The pipe then pitches down from the boiler in every direction and, at the extreme ends of the runs, is dropped to a point near the floor line and connected into the return. The flow pipe for the rising lines and near the floor is taken off the side of the main. All the returns drop into the return main and are preferably connected into the side of same.

In Fig. 227 is shown a line of radiators connected with risers. Here the riser leaves the main 1¼ inch. After it leaves the first floor it is reduced to 1 inch and again reduced to ¾ inch for the third floor. The radiator connections may all

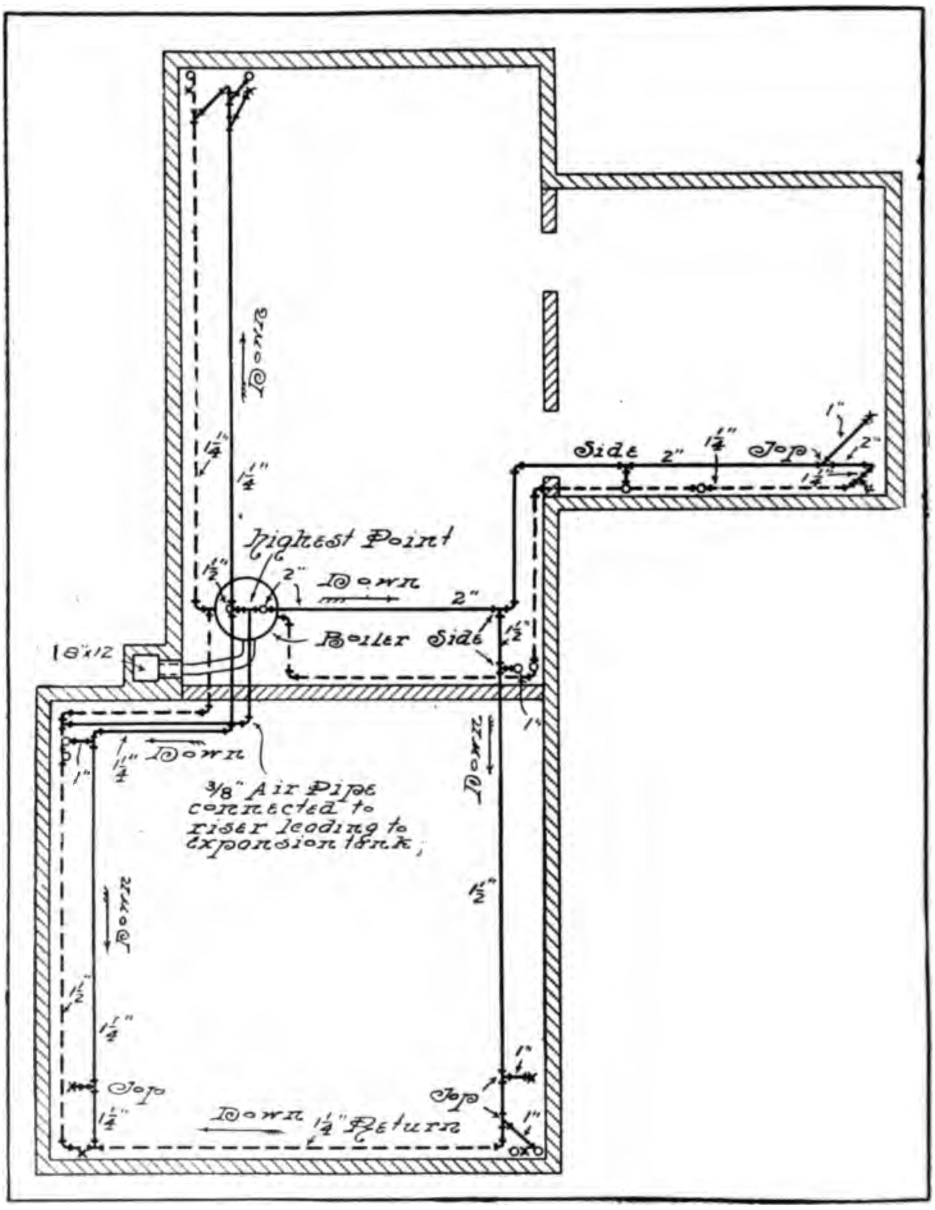


FIG. 228—OLD HOUSE HEATED WITH WATER. PIPING PLAN, **BASEMENT 6 FT. 6 IN.**

be ¾ inch, as each radiator contains only 40 square feet.

Fig. 226 is a view of the boiler showing the 2½-inch flow pipe and the air line rising from same. Figs. 228, 229, 230 and 231 are plans of a hot-water heating apparatus recently installed in an old house.

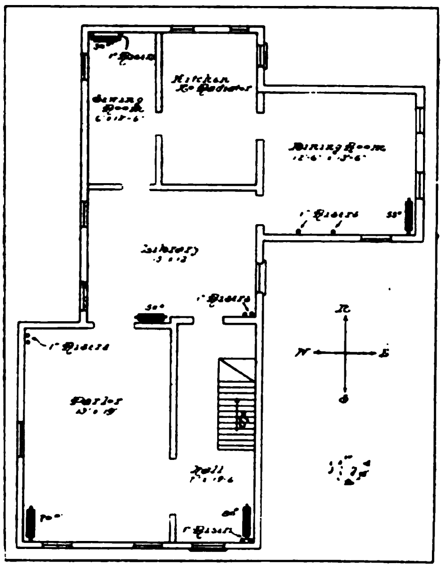


FIG. 229—OLD HOUSE HEATED WITH HOT WATER. RISERS EXPOSED

There are 470 square feet of radiation in the house, which is carried by a boiler with 21-inch grate, the catalog rating of which is 750 square feet. From the top of the boiler a 2-inch and a 1½-inch pipe rise, which are connected together at the top and from there is carried an air line which is connected into the nearest riser. The pipes then pitch down from the boiler in every direction, drop at their extreme ends, and are carried back on the wall within two feet of the floor line. Thus all the air in the basement piping is taken off at the boiler through the ¾-inch air line and delivered into the return riser, which connects directly with the expansion tank in the closet on the second floor, as shown in Fig. 231.

This method of water piping is becoming popular with all who have tried it. It certainly gives better results than does the regular method of rising from the boiler where the end of the pipe terminates in a radiator connection.

In the style of piping shown in Fig. 229 the ends of the pipe are connected together and create a rapid circulation through the entire line of piping, so that every radiator connected to the line gets the benefit of this increased circulation.

In this apparatus which we are discussing every radiator in the house will heat evenly throughout when the water at the boiler is at or about 100 deg. F. temperature. It is very rarely that any method of hot water heating distributes the water as evenly as does this little heating job. Besides this, when the fire is kindled in the boiler the circulation is wonderfully rapid and the temperature of the house can be raised very rapidly.

The quantity of radiation necessary to heat this house was determined by apportioning one square foot of radiation to 200 cubic feet of space. One square foot of radiation to 12 square feet of exposed wall, and 1 square foot to 3 square feet of window opening. These factors give the quantities of radiation for low pressure steam heating, to which was added

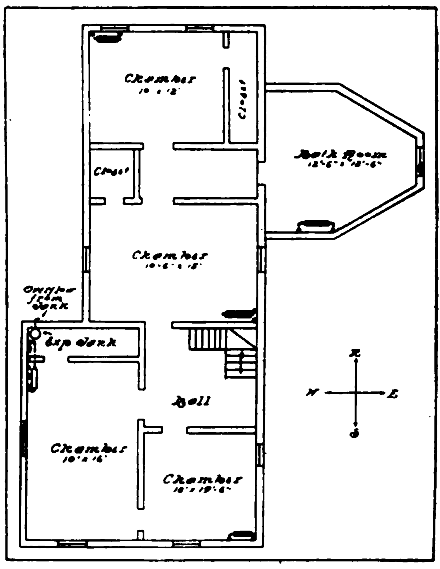


FIG. 230—AN OLD HOUSE HEATED WITH HOT WATER. SECOND FLOOR PLAN. CEILING 8 FT. 6 IN.

60 per cent. to make the equivalent radiation required for water, with a mean temperature in the radiators of 170 degrees F.

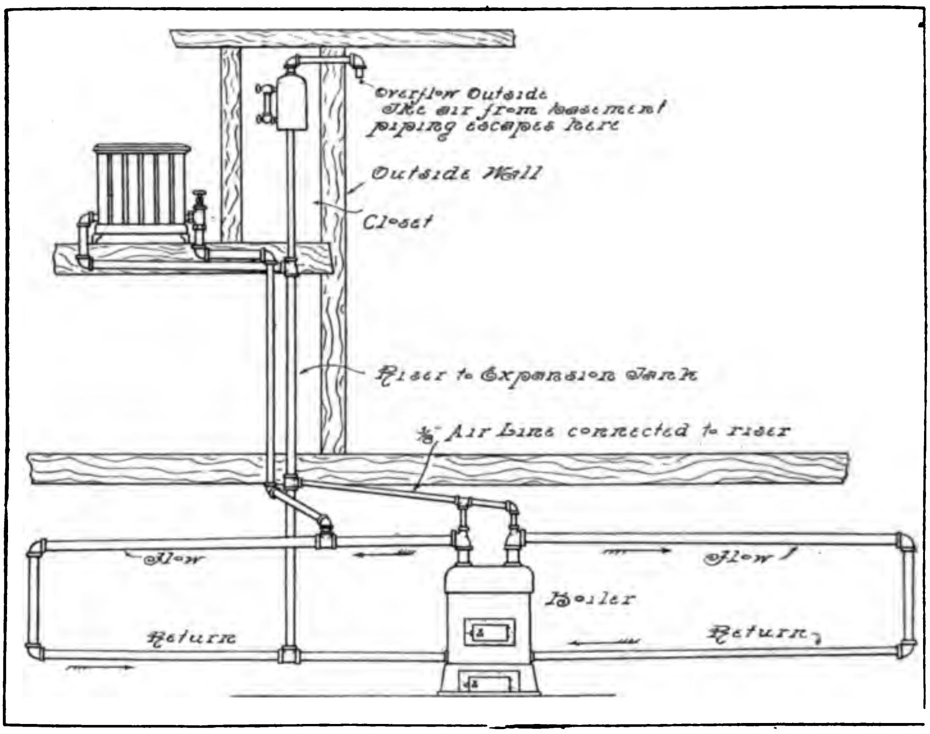


FIG. 231—OLD HOUSE HEATED WITH WATER. ELEVATION SHOWS BOILER AND TANK CONNECTIONS AND PIPE GRADE

CHAPTER LI.

SMALL PIPE FOR WATER HEATING APPARATUS.

> I PROPOSE installing a hot water heating plant in accordance with basement plans submitted herewith.
>
> "This is my first experience in using this system, having heretofore always used larger sized pipes, reducing them as the radiation was taken off, and none of which have come up to my expectations in the matter of efficiency.
>
> "I have been following closely the articles of Mr. Thompson for past few months and am greatly interested. Will you kindly submit enclosed plan to him for his advice?
>
> "Any suggestions or alterations he may make will be most highly appreciated. I propose taking branches for upstairs off the side and for downstairs, on a 45 degree. Is this right?
>
> "T."

We reproduce herewith the basement and first and second floor plans sent us by our correspondent, and have made a few changes in the pipe sizes, but not in the arrangement of the piping or in the position of the radiators.

Looking at the piping plan, in the basement, Fig. 232, we show one line of 2-inch pipe rising from the boiler, and connecting into two 2-inch lines. This is shown clearly in Fig. 235, where each line of 2-inch pipe pitches down from the single 2-inch pipe which rises from the boiler. This rising pipe should be carried as high as possible, and from the top of the tee a ⅜-inch pipe should be carried either to the expansion pipe or into the nearest riser to the main, because that is the high point of the basement piping.

From that point both lines of 2-inch pipe pitch down just sufficiently to drain the water out of the pipes, until the last radiator is reached on each line. At that point a 2 x 1½-inch ell is placed on the feed pipe looking down; the 1½-inch return drops to a point above the floor line, a few inches higher than the return tapping of the boiler, so that if the boiler is emptied of water all the water in the apparatus will empty through these returns into the boiler and out of the boiler through the drain cock.

Line "A" carries 410 square feet; the first radiator is on the first floor, containing 60 square feet, and sets quite near to the boiler. To prevent this radiator heating much ahead of the others, a 1-inch pipe is taken out of the side of the 2-inch main and carried to a point underneath the radiator, where it is fitted with a 1 x ¾-inch ell. The ¾-inch pipe rises to the radiator, which is fitted with a three-quarter angle valve. The return from this radiator may be ¾-inch and dropped directly into the 1½-inch return.

The next radiator is on the second floor and contains 45 square feet. To feed this radiator, a 1-inch pipe is run to a point in the basement underneath the foot of the riser, 1-inch in size, the riser itself being ¾-inch, and the valve of the radiator being also ¾-inch.

The next radiator on this line contains 80 square feet on first floor and is fed by a 1¼-inch arm and a 1-inch riser and valve, the connection being taken from the top of the main.

The next radiator on the line is on the second floor and contains 45 square feet. It is fed by a 1-inch arm and ¾-inch riser and valve. This line is taken from the top of the main.

The next radiator is on the first floor, contains 65 square feet, and is supplied with a 1¼-inch arm and a 1-inch riser and valve, and is fed from the top of the main.

The next radiator on this line is on

the second floor, contains 40 square feet, and is fed from the top of the main with a 1-inch arm and ¾-inch riser and valve.

The next radiator is on the first floor, contains 40 square feet, and is fed from the top of the main by a 1-inch arm and ¾-inch riser and valve.

The last radiator on the line is on the second floor, contains 35 square feet, and is fed from the top of the main with a 1-inch arm and ¾-inch riser and valve.

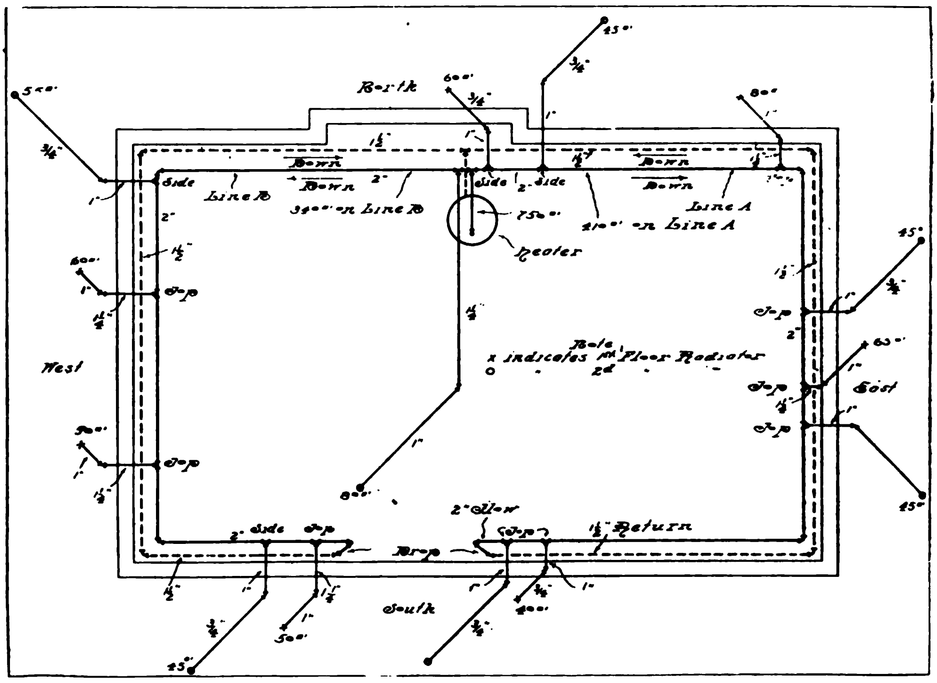


FIG. 232—BASEMENT PLAN. ONE LINE OF 2-INCH PIPE RISES FROM BOILER AND CONNECTS INTO TWO 2-INCH LINES

Line B carries 340 square feet of radiation. The first radiator taken off this line is on the second floor, contains 80 square feet, and is fed from a point near the boiler, from the top of the main, with a 1¼-inch arm and a 1-inch riser and valve.

The next radiator on line B is on the second floor, contains 55 square feet, and is fed from the side of the main with a 1-inch arm and ¾-inch riser and valve.

The next radiator is on the first floor. This radiator contains 60 square feet, and is fed from the top of the main by means of a 1¼-inch arm and a 1-inch riser and valve.

The next radiator on the line is on the first floor, contains 50 square feet, and is fed from the top of the main with a 1¼-inch arm and 1-inch riser and valve.

The next radiator is on the second floor, contains 45 square feet, and is fed from the side of the main with a 1-inch arm and ¾-inch riser and valve.

The last radiator on the line is on the first floor, contains 50 square feet, and is fed from the top of the main with a 1¼-inch arm and a 1-inch riser and valve.

The writer is aware that these pipe sizes are innovations, and that ninety-nine men out of one hundred in the trade will condemn them, but these sizes are not given by guesswork, but because we know from actual practice that a water heating apparatus equipped as designated by these plans and under these directions will circulate faster, give a more even

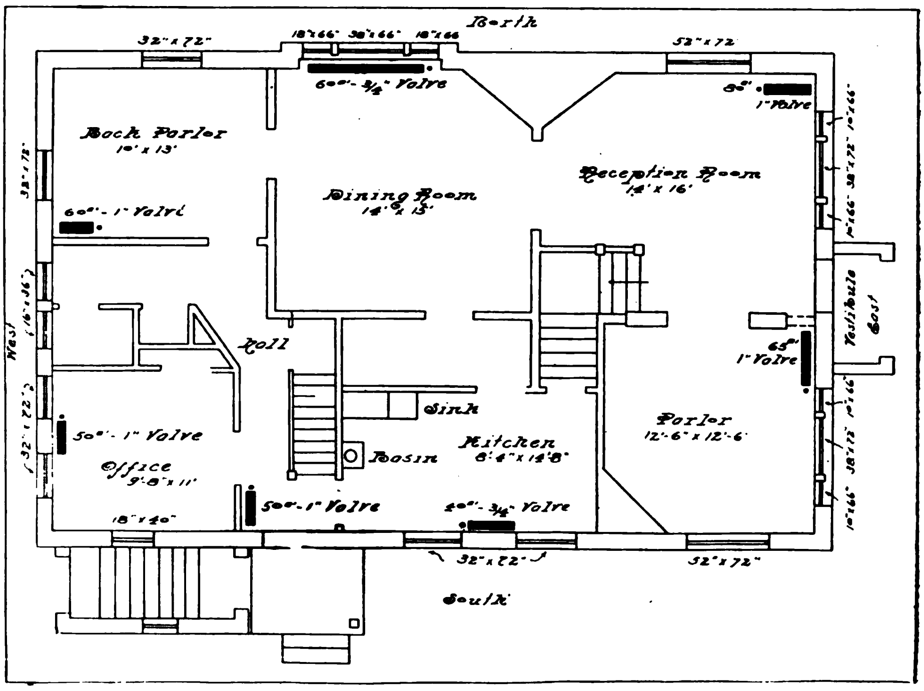


FIG. 233—IN WHICH IS SHOWN DIAGRAM OF FIRST FLOOR PLAN OF HOUSE

heat in all of the radiation, and operate with less fuel than will the usual run of hot water piping.

Reverting for a moment to Fig. 235, which shows one 2-inch pipe carrying 750 square feet of radiation and feeding

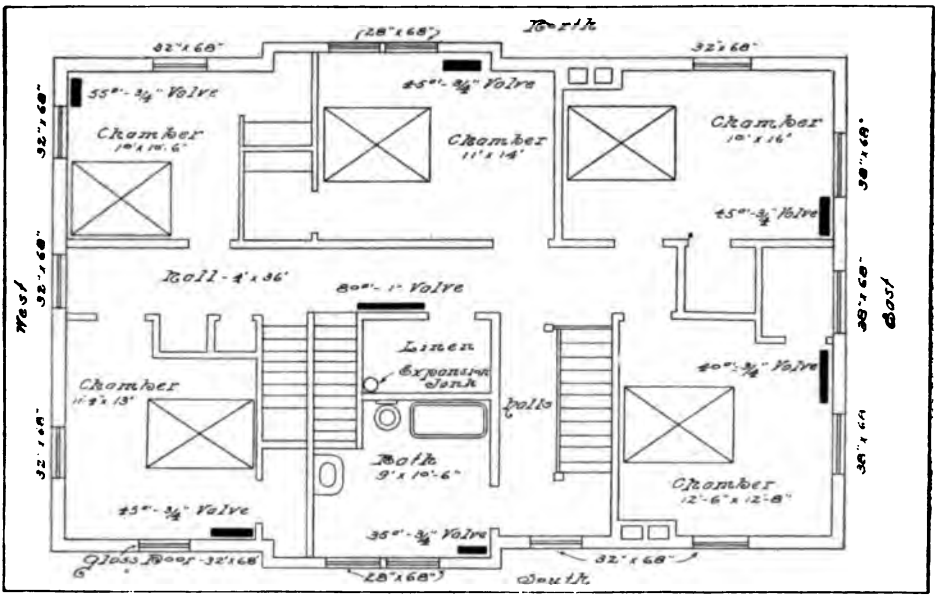


FIG. 234—SECOND FLOOR PLAN—SKETCH SHOWING THE ARRANGEMENT OF RADIATORS

two 2-inch mains. This will undoubtedly be severely criticised, but, if our correspondent will try it, he will be astonished to find how much more rapidly the water will circulate through the radiation than it will where each branch is connected directly to the boiler.

It will not be necessary in this kind of piping to use twin ells or fittings with dams in them, or sign posts, in order to give the water direction. There will be no need, whatever, for any such devices, and the only reason for feeding some of the radiators from the side of the flow pipe, is to maintain a more even temperature in the various radiators.

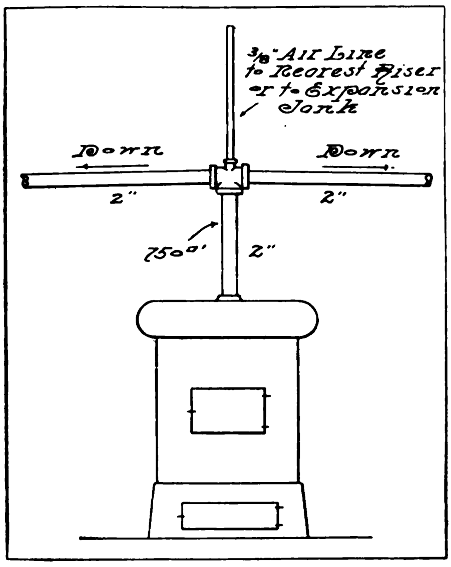


FIG. 235—SHOWING ONE 2-INCH PIPE CARRYING 750 SQUARE FEET OF RADIATION AND FEEDING TWO 2-INCH MAINS

It may seem strange to recommend a 1½-inch return with a 2-inch line for hot water heating. It is usual to run the flow and return the same size, but there are many installations where the return pipe could well be cut down at least one size smaller and get the same, if not better, results.

In the present instance, the reason for running the returns one size smaller than the flow pipe is because we know that a 1½-inch pipe will carry all the radiation that is now placed on the 2-inch lines, but there would be a little more loss of heat at the end of the line than is to be found in the 2-inch. Therefore, we show the flow pipe 2-inch, simply to maintain the temperature of the water, and show the return pipe 1½-inch, which will carry the water back to the boiler, but at a higher velocity than obtains in the 2-inch line.

Our correspondent need have no hesitation in installing the apparatus exactly as shown by these drawings. Several jobs of about this size were installed in the writer's immediate vicinity last year, and have been a surprise to every one who has seen them in operation, and they are also an agreeable surprise to the people who furnish the fuel to run them. In every case where this small pipe with high velocity has been employed, the fuel demand has been considerably less than anticipated, and so far as cost is concerned, it requires no argument to show that not only is the actual cost of the piping and fittings less, but the labor for installing small pipe does not cost as much as for the large sizes.

In one installation, the writer has in mind, there are two 1½-inch pipes leaving the boiler, very similar to the line of pipe shown in this sketch. These two 1½-inch flow pipes enter one 1½-inch return the entire radiation being a little over 600 square feet.

We hear more of frictional resistance in water heating than of velocities, though we consider it of much more importance to have high velocities where we can use small piping and get results, than to try to avoid friction, by using excessive pipe sizes, and loading the apparatus down with hundreds of gallons of water, which require vast quantities of fuel to maintain its temperature.

In many of these large piped water heating apparatus with active combustion, the velocity in the mains will not exceed more than one foot in ten seconds.

In an apparatus designed as shown in this sketch, with the water leaving the boiler at 180 degrees, the velocity through the 2-inch main will approximate 6 feet per second.

CHAPTER LII.

WATER HEATING APPARATUS FOR A VIRGINIA RESIDENCE.

I AM enclosing plans of a house, with the window glass, exposed wall and cubic contents figured out for each room which is to be warmed. I would like to have you publish this in your next issue, showing the amount of radiation required to heat the building with a hot water system.

The house is located in an exposed place, on a hill, right in the open, and is built of good frame construction. The location is in the western part of Virginia, and the radiation should be figured to maintain a temperature in the rooms of 70 degrees when the outside temperature is at zero. INQUIRER.

We reproduce herewith the floor plans sent in by our correspondent, and have placed the radiation as indicated by him in his sketch, although we do not approve of placing a radiator under every window in the room. It makes a house look too much like a show room for radiators. There is no necessity for placing a radiator under every window. In fact, unless there is a window seat over it, there is the objection that the upward

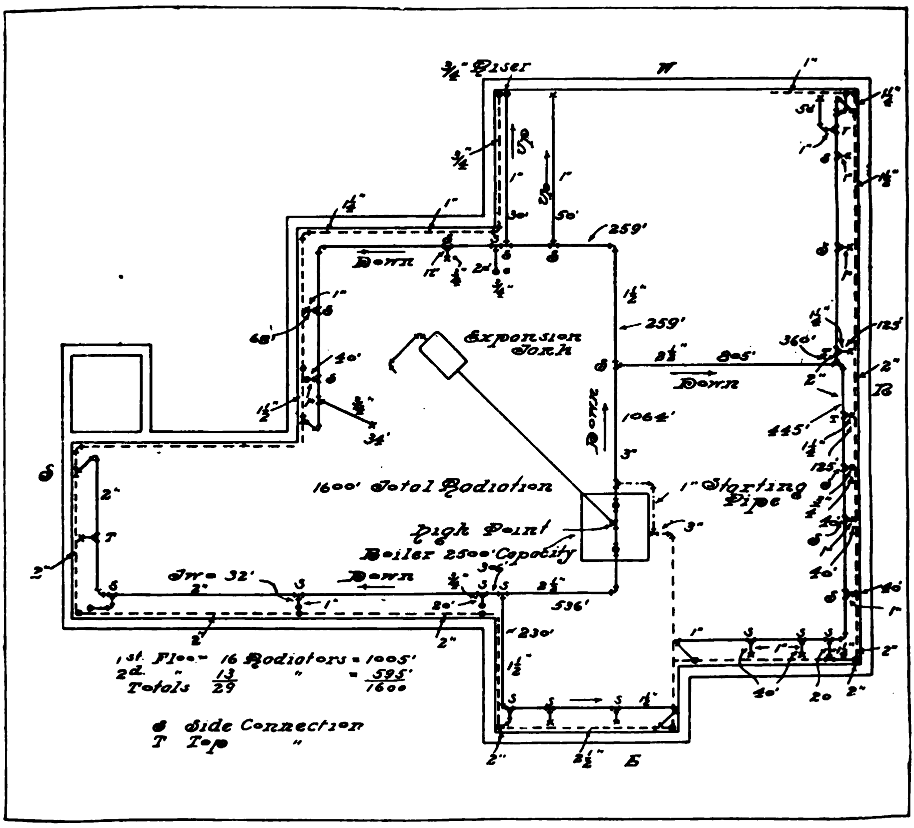


FIG. 236—SKETCH SHOWING BASEMENT PLAN OF HOUSE TO BE HEATED BY HOT WATER

currents of air passing through the radiator, will deposit dirt on the white curtains, which is a serious objection.

In room 16, there are four radiators of 40 square feet each. These could just as well be cut down to two radiators of 80 square feet each, placed between the windows on the outside walls.

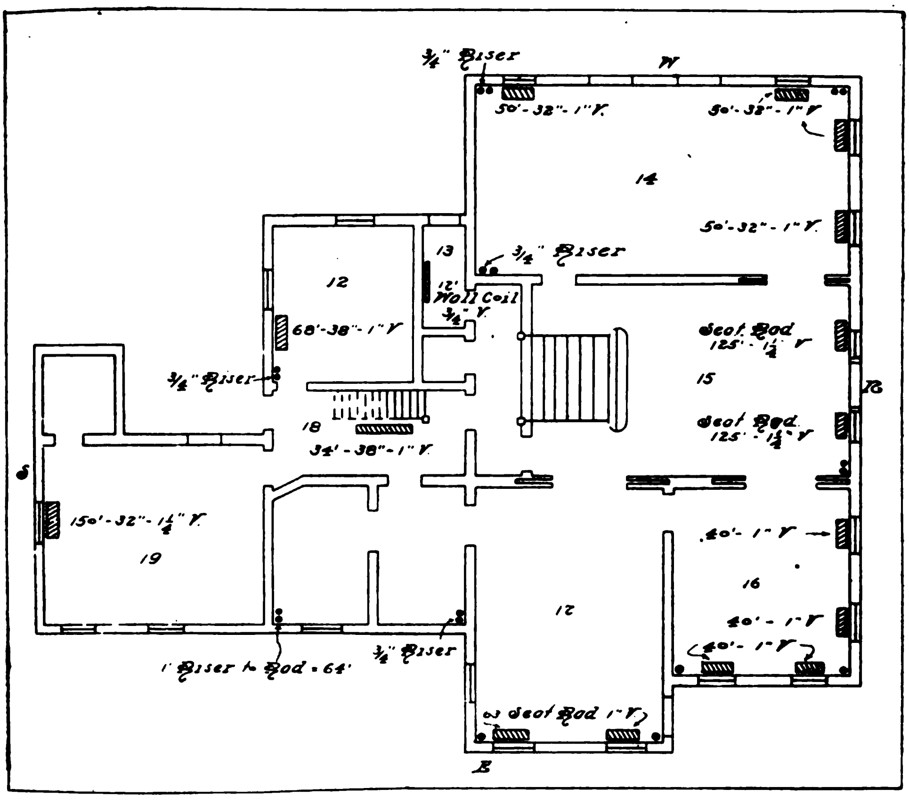


FIG. 237—DIAGRAM OF FIRST FLOOR OF HOUSE LOCATED IN WEST VIRGINIA

The two radiators in the main hall, having seats over them, will look all right, but care must be taken not to push the seat down close to the top of the radiator. There should be a space between the top of the radiator and the seat of at least 3 inches, and the wall back of the radiator and the bottom of the seat should be lined with metal in one piece, rising gradually to the front so that the air may flow freely out through the front of the radiator. Fig. 240 shows the proper method for the installation of window seat radiation. The metal lining may be of light zinc or light galvanized iron, or in some cases where expense is not considered, planished copper is used, but a very light zinc is as good as anything. There should be no obstruction in front of the radiator. If the front is filled with close grill work, or if the apron is dropped from the edge of the seat as is shown in Fig. 241, the air is confined and the efficiency of the radiator falls off very materially. The same thing happens if the seat is placed too near the top of the radiator. The method of installation shown in Fig. 241 is very often resorted to and time and again, radiation boxed in in this manner, has proved inefficient. The most inexperienced heating contractor would scarcely expect to get much heat from a radiator which is cased up in a box, and yet in Fig. 241 the radiator is almost cased in.

There are many who have the idea that if the radiator can be heated, the heat will find itself out in some way, but where a radiator is so hemmed in that the heat cannot pass freely over it, it does not cool the water or the steam, with which it may be filled, and consequently being surrounded by air of a very high temperature, the efficiency of the radiator falls off anywhere from 50 to 80 per cent.

If it is not convenient, or not sufficient to support the seat at the two ends, it may be supported by a small iron rod or a piece of ¾-inch pipe, fitted with floor flanges, one flange resting on the radiator, the other flange resting on the metal lining, backed by a piece of wood between the lining and the seat. See Fig. 242.

In room 14, there are four radiators, containing 50 square feet each; these radiators might be reduced to three.

As the temperature of the rooms in the house must be maintained at 70 degrees, when it is zero outside, we assume that the mean temperature of the radiator, under those conditions, will be 170 degrees. We figure that each square foot of glass under such conditions, will lose

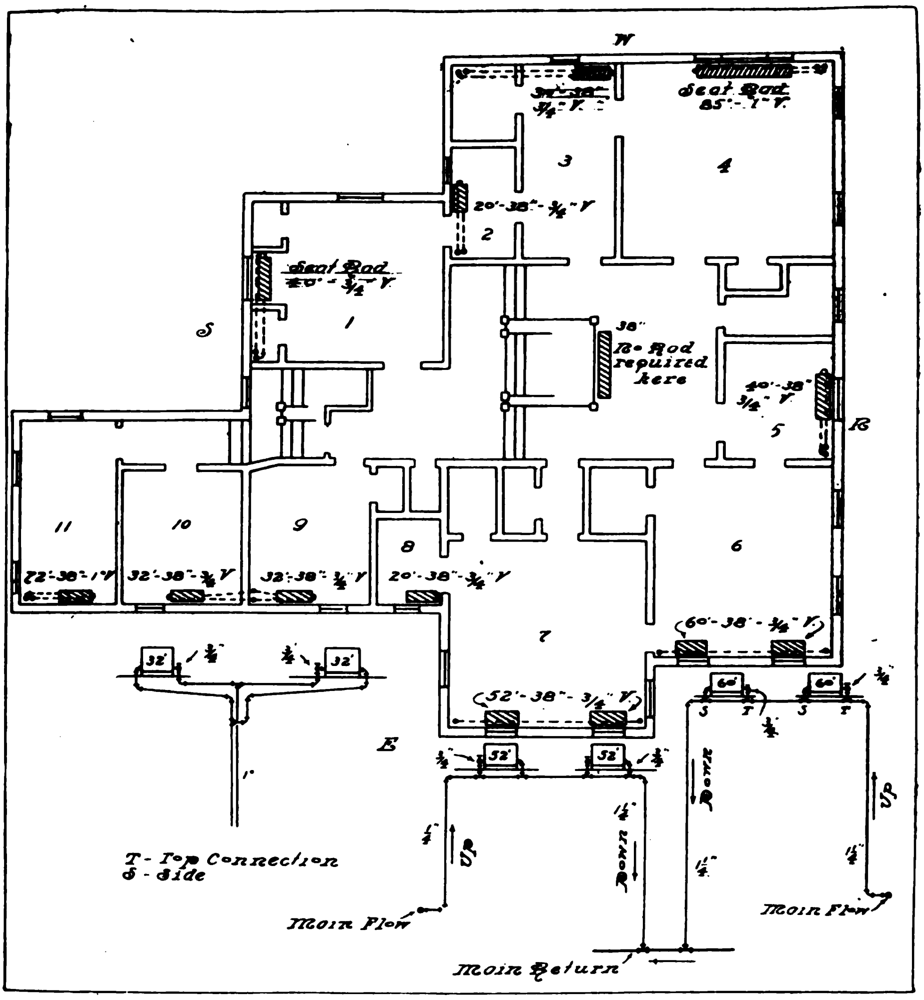


FIG. 238—DIAGRAM OF SECOND FLOOR PLNN SHOWING SIDE AND TOP CONNECTIONS

72 B. T. U. per hour; each square foot of wall will lose 22 B. T. U. per hour; and that each cubic foot of air in the room will require 1.4 B. T. U. to raise its temperature from zero up to 70 degrees.

We figure that the air will change twice per hour in the hall and one per hour in the various rooms. We assume that the radiation, under those conditions will emit 150 B. T. U. per square foot per hour, and from this data, we establish the following factors:

Glass, divide by 2
Wall, divide by 7
Cubic feet of air, divide by 120

The rooms on the first floor contain as follows:

Room 16......72 ft. of glass;
419 ft. wall and 3464 cu. ft. of air
Front wall....80 ft. of glass;
118 ft. wall and 12276 cu. ft. of air
Room 14.....128 ft. of glass;
488 ft. wall and 6743 cu. ft. of air
Room 17......93 ft. of glass;
281 ft. wall and 4716 cu. ft. of air
Room 19......93 ft. of glass;
479 ft. wall and 3927 cu. ft. of air
Room 12......54 ft. of glass;
191 ft. wall and 1680 cu. ft. of air
Room 18......21 ft. of glass;
34 ft. wall and 2310 cu. ft. of air
Room 13......25 ft. of glass;
19 ft. wall and 528 cu. ft. of air

The rooms on the second floor contain as follows:

Room 1......18 ft. of glass;
127 ft. wall and 1643 cu. ft. of air
Room 2......15 ft. of glass;
40 ft. wall and 550 cu. ft. of air
Room 3......15 ft. of glass;
70 ft. wall and 1530 cu. ft. of air
Room 4......75 ft. of glass;
95 ft. wall and 3400 cu. ft. of air
Room 5......27 ft. of glass;
83 ft. wall and 1100 cu. ft. of air
Room 6......72 ft. of glass;
381 ft. wall and 3150 cu. ft. of air
Room 7......93 ft. of glass;
256 ft. wall and 2890 cu. ft. of air
Room 8......18 ft. of glass;
32 ft. wall and 570 cu. ft. of air
Room 9......15 ft. of glass;
95 ft. wall and 1540 cu. ft. of air
Room 10......15 ft. of glass;
100 ft. wall and 1500 cu. ft. of air
Room 11......30 ft. of glass;
320 ft. wall and 1530 cu. ft. of air

The upper halls do not require any radiation as they are heated from below, and there is no place for the air to cool in the upper hall, unless it may be a sky-light, which the plans do not indicate. If such should be the case, it might be well to place a radiator of about 60 square feet in the upper hall.

In rooms 6 and 7 on the second floor, there are two radiators in each, and the arrangement of the pipe connections for these radiators is shown in a sketch adjoining the rooms. This will be the best possible way in which to connect those radiators. The risers can then stand in the corners of the rooms where they will not be conspicuous. The flow pipe or risers to these radiators are connected to the side of the main in the basement. They rise to the second floor and are carried along under the floor, beneath the radiators. The feed or flow pipe to the radiators is taken off the top and the return dropped into side of this pipe.

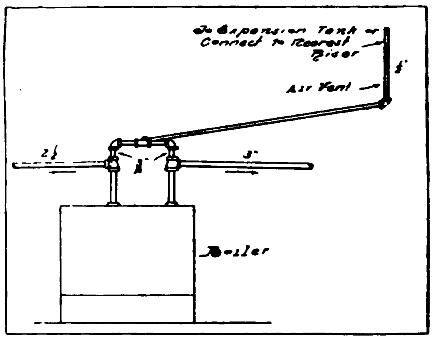


FIG. 239—SHOWING BOILER CONNECTIONS

If our correspondent has never tried this method of radiator connection, he need have no hesitation in adopting it as it has been successfully practiced by the writer and others for years.

The ¾-inch valves shown on these radiators are sufficiently large, and will furnish all the heat that could be obtained by using a valve of a larger size.

The total quantity of radiation in this house is 1,600 square feet, and if we were figuring to warm a house located in Virginia, without special instructions as to climatic conditions, we would figure it on a basis of 20 degrees above zero external temperature and 70 degrees internal temperature; a temperature difference of 50 degrees. This would reduce the radiation to 1,150 square feet, which will maintain a temperature of 70 degrees in the rooms so long as the outside temperature does not drop below 20 degrees.

For the few severe days which occasionally visit the locality, we would run the water at a higher temperature, say between 190 and 200 degrees, which will give the same results as the additional radiation.

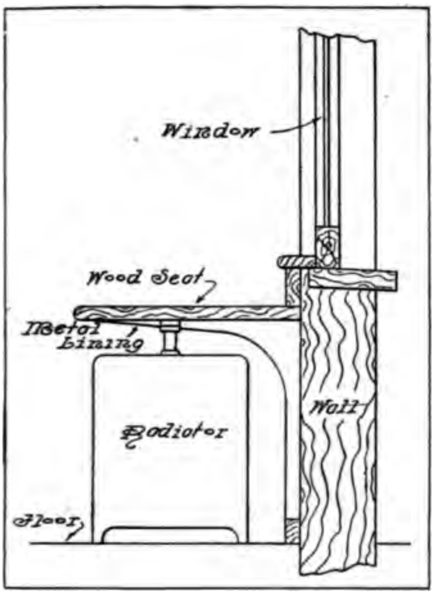


FIG. 240—SKETCH OF WINDOW SEAT RADIATION PROPERLY INSTALLED

This can easily be arranged by having a boiler of the capacity which we have suggested, namely, 2,500 square feet.

If our correspondent wishes to take advantage of this hint, he may multiply the radiation specified for the various rooms by the decimal 0.72. This will reduce the radiation in room 16 from 160 to 115 square feet, and in room 14 from 200 to 144 square feet.

If such a plan is adopted, we would use a very large expansion tank, and there is nothing better for the purpose than a 40-gallon range boiler. If it is 60-gallon, so much the better, as it gives plenty of room for the expansion of the water when raised to a high temperature.

The arrangement and size of the piping is shown in the basement plan, Fig. 236. As there are 1,600 square feet of radiation, there will be about 400 square feet of pipe, making a boiler load of 2,000 square feet, to which we have added 25 per cent. for reserve power, and have selected a boiler of 2,500 square feet capacity. In selecting a boiler of this size, we get a fuel capacity which will maintain a fire through the long winter nights and which will require much less stoking than a boiler of smaller dimensions. The style of piping shown is that with which the writer has achieved the greatest success, and it has been thoroughly tested in the past ten yearsthe past ten years. It the past ten years. It is what we would call "falling circulation."

The pipes rise from the boiler to the highest possible point in the basement, and from that point the air is taken in a small air line, which may be connected to the nearest riser, in which event, the air is taken off through air valves on the radiator. A better method, however, is to run this air line and connect it to the expansion tank, and it will then serve as well for the expansion pipe. The air is then vented freely through the expansion tank and carried out of doors, or wherever the overflow pipe leads to. The piping is divided up so that the heat

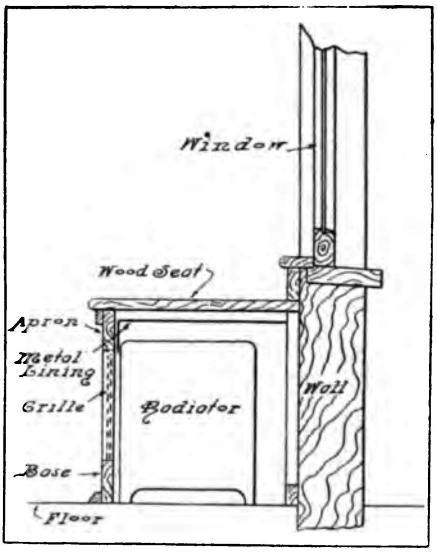


FIG. 241—SHOWING WINDOW SEAT RADIATOR IMPROPERLY INSTALLED

reaches the radiation by the shortest route.

The 3-inch line on the west side of the building carries 1,064 square feet. From the side of this 3-inch main, a 2½-inch branch is taken, which carries 805 square feet. This 2½-inch line terminates in two 2-inch lines; one running west and carrying 360 square feet; the other running east and carrying 445 square feet.

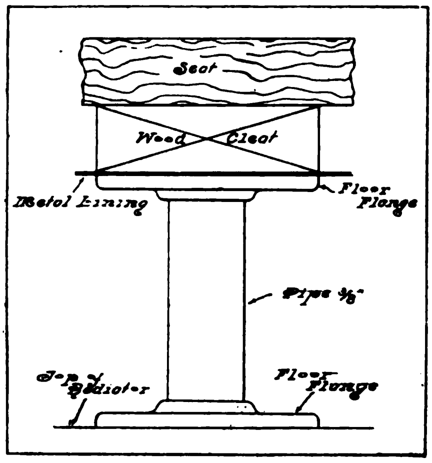


FIG. 242 ENLARGED VIEW OF SEAT SUPPORT

From the junction of the 3-inch and 2½-inch mains, a 1½-inch main takes care of 259 square feet. It will be noticed that these three lines of pipe pitch down from the boiler, and after all the radiation is connected, the end of the line is carried out a foot or two past the last connection and is there dropped and connected to the return line which is carried along the wall about 18 or 24 inches above the floor line.

On the east side of the building, a 2½-inch main leaves the boiler, carrying 536 square feet. From the side of this main, a 1½-inch pipe carries 230 square feet, and a 2-inch main which runs to the rear end of the house, under the kitchen, carries 306 square feet.

All the connections except those which are specially marked, are taken from the side of the main. In taking the flow pipe from the side of the main, a much better distribution of heat can be had, than when the mains are taken off the top or with a 45-degree elbow. The connections which are to be taken from the top of the main are marked "T"; those which are to be taken from the side are marked "S."

The advantage of this kind of piping is that the drop at the end of the main is always the coldest water, and the return from each and every radiator being dropped directly into this return, causes a very rapid circulation and permits the use of much smaller pipe than is possible with the old method of rising circulation, with the main return dropped at the boiler.

It will be noted that there is only one 3-inch return to carry the water contained in one 3-inch and in one 2½-inch pipes, and this method of piping will doubtless be criticised by those who have had no means of measuring the result of

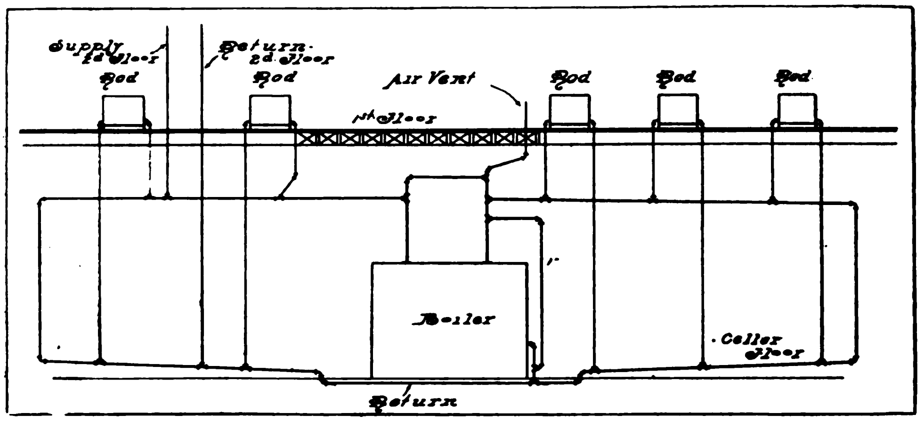


FIG. 243—SECTION OF PIPE LINES FOR HEATING HOUSE IN VIRGINIA

such work. This system, however, has been thoroughly tried and carefully measured with exact instruments, and it is a fact that the only difference noticed is the higher velocity in the return pipe, caused by the pipe being somewhat smaller. The only reason for carrying so large a pipe for conveying the water to the radiators, is to prevent the water cooling down too rapidly.

The matter of distribution will take care of itself. Where the return pipe connects to the boiler, it will be necessary to carry it below the basement floor, which will necessitate a rise of about 24 inches at the boiler. To lighten the water in this rising pipe, which would otherwise retard rapid circulation, a 1-inch pipe is carried from the 3-inch rising line of the boiler and is connected to the bottom part of the rising return line. See Fig. 243. The hot water flowing from the top of the boiler to the bottom of this line will lighten the water and facilitate circulation.

The returns from the radiators are not shown, it being understood that the returns from every radiator and riser drop directly into the main return in the basement.

CHAPTER LIII.

A GOOD EXAMPLE OF MODERN WATER HEATING APPARATUS.

As a good example of hot water heating, with "safe and sane" piping, we present first and second floor plans, and also basement plans of an old residence, located in western New York, in which has recently been installed the heating apparatus described in this article.

The height of the ceilings on the first floor are 11 feet; on the second floor, 10 feet; in the basement, 7 feet 6 inches.

In computing the radiation, it is assumed that the air in the various living rooms and bed rooms, will change once per hour, and that the air in the hallways will change twice per hour.

As the apparatus is intended to maintain a temperature of 70 degrees in every room equipped with radiation, when the external temperature is at zero, the heat loss is calculated as follows: Each square foot of window, which includes glass and sash will lose 72 B. T. U. per hour. Each square foot of exposed wall will lose 22 B. T. U. per hour. Each cubic foot of air space will require 1.4 B. T. U. to raise its temperature from zero to 70 degrees, or through 70 degrees of temperature.

It is calculated that for the maximum demand, the radiation will be maintained at a mean temperature of 170 degrees, and that with this condition prevailing, each square foot of radiation will emit or give off 150 B. T. U. per hour.

To save an excessive amount of figuring, this data has been resolved into the following factors or divisors:

Glass or window openings, divide by 2.
Exposed wall, divide by 7.
Cubic feet of space, divide by 120.

That is, one square foot of radiation is apportioned to 2 square feet of glass; one square foot of radiation to 7 square feet of exposed wall, and 1 square foot of radiation to 120 cubic feet of air.

In the main hall, there are

12 square feet of glass.
110 square feet of exposed wall.
3025 cubic feet of air × 2 = 6050 cubic feet.

The radiator which is located in the front part of the hall, is 38 inches high and contains 75 square feet. This quantity of radiation will take care of the second floor hall as well.

In the parlor, there are

57 square feet of glass.
237 square feet of exposed wall.
2700 cubic feet of air.

In this room, the radiator is placed under the front window, is 18 inches high and contains 106.5 square feet.

42 square feet of glass.
286 square feet of exposed wall.
1850 cubic feet of air space.

The radiator is placed under the window, is 18 inches high and contains 53 1/3 square feet.

In the laboratory, there are

15 square feet of glass.
77 square feet of exposed wall.
385 cubic feet of air.

The radiator is placed under the window, is 18 inches high and contains 20¼ square feet.

The private office has

21 square feet of glass.
275 square feet of exposed wall.
1716 cubic feet of air.

The radiator is placed on the rear wall, is 38 inches high and contains 65 square feet.

The dining room has

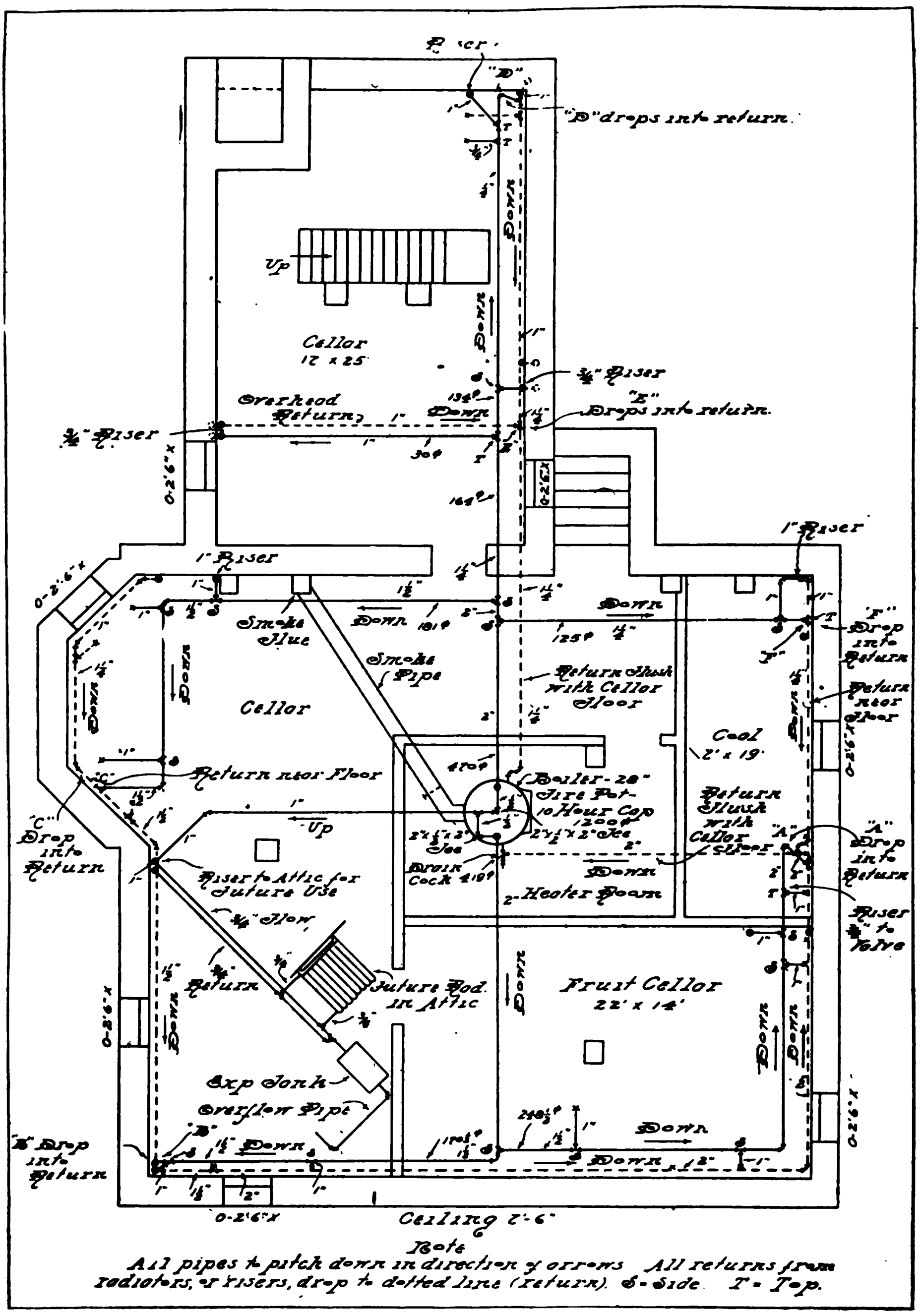
72 square feet of glass.
231 square feet of exposed wall.
2890 cubic feet of air.

There are two radiators in this room, which are placed under the windows.

They are 20 inches high and each contains 48 square feet.

The toilet room at the rear part of the house contains 9 square feet of wall radiation.

There is no radiator in the kitchen.



Note
All pipes to pitch down in direction of arrows. All returns from radiators, or risers, drop to dotted line (return). S = Side. T = Top.

FIG. 244—BASEMENT PLAN SHOWING THE LOCATION OF HEATER, PIPING, ETC.

The risers are shown in the plan, exposed in the rooms, but in many cases these risers might well be concealed in the partitions.

The radiators on the first floor which contain respectively 25, 20¼ and 9 square feet are connected ¾ inch. All the other radiators are connected 1 inch, both flow

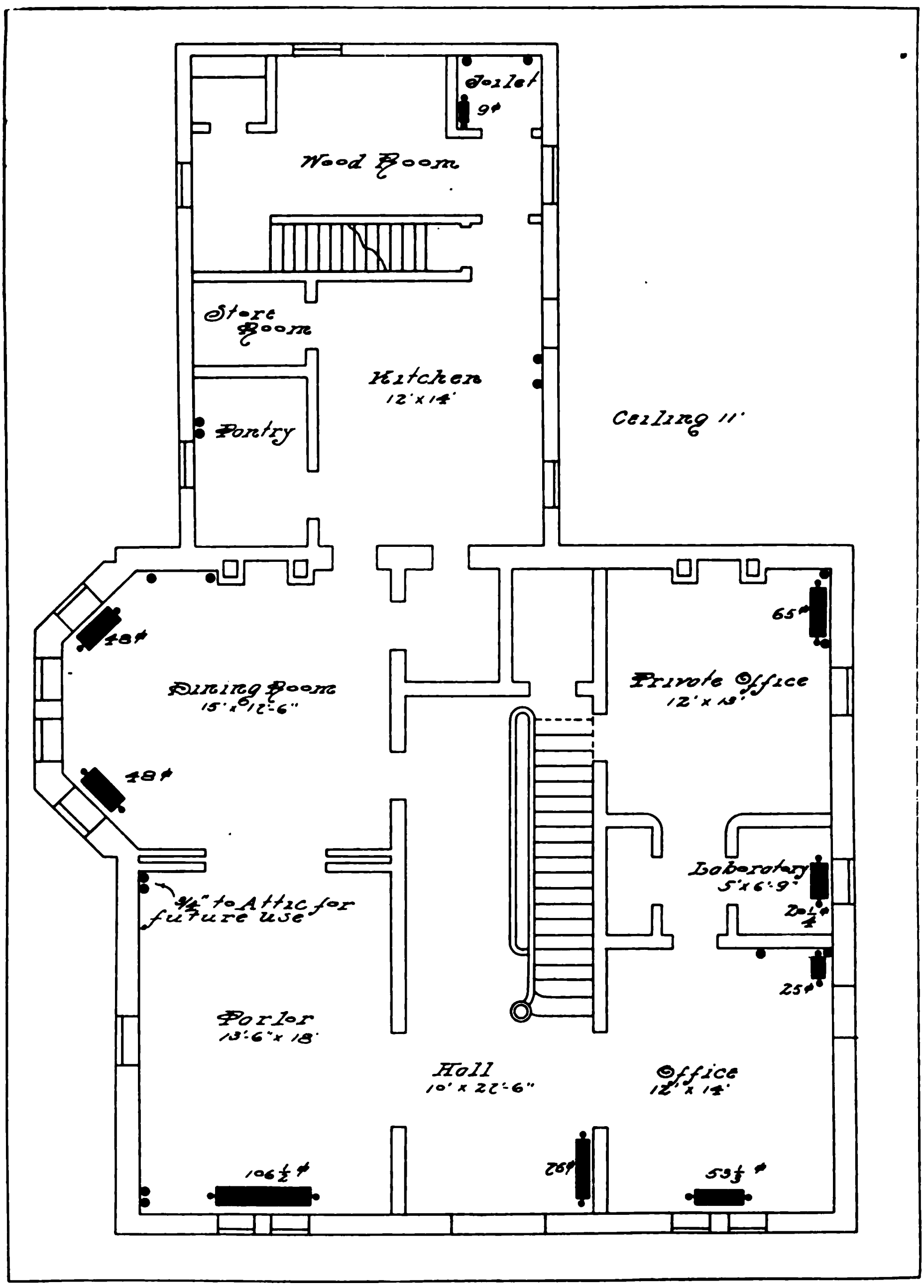


FIG. 245—FIRST FLOOR PLAN OF RESIDENCE SHOWING LOCATION OF KITCHEN, PANTRY, ETC

and return, which is large enough.

On the second floor, chamber No. 1 has

36 square feet of glass.
280 square feet of exposed wall.
2025 cubic feet of air.

The radiator for this room is placed in the corner of the two exposed walls, is 38 inches high and contains 75 square

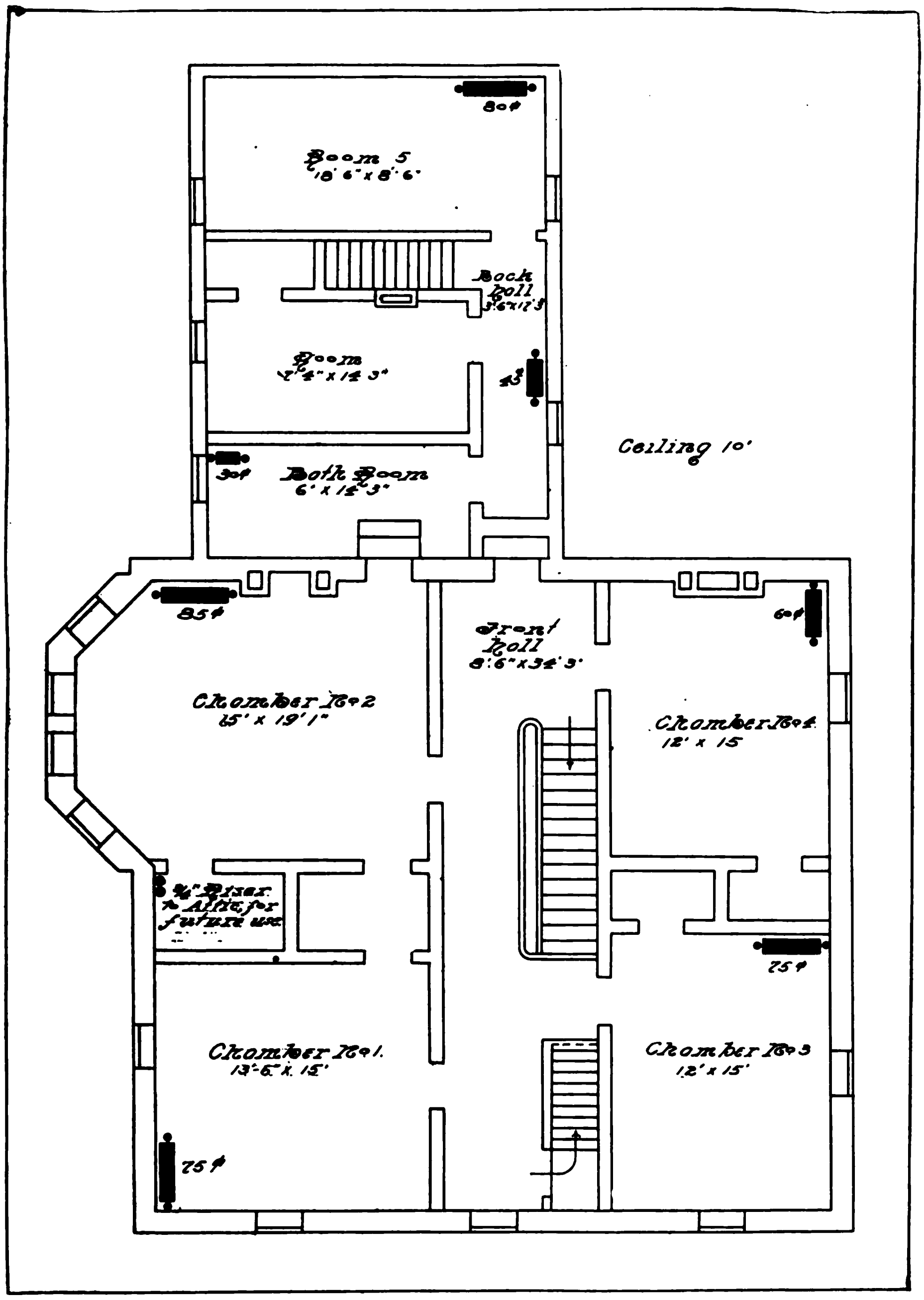


FIG. 246—PLAN OF THE SECOND FLOOR IN A RESIDENCE IN WESTERN NEW YORK

feet (ratio 1 to 27 cubic feet).

Chamber No. 2 contains

72 square feet of glass.
215 square feet of exposed wall.
2800 cubic feet of air.

The radiator is placed on the side wall near the windows, is 38 inches high, and contains 85 square feet.

Chamber No. 3 has

36 square feet of glass.
270 square feet of exposed wall.
1800 cubic feet of air.

The radiator is placed on the rear inside wall of the room, is 38 inches high and contains 75 square feet.

It is usual to place direct radiation near the outside walls and when so placed it has the effect of intercepting the cold air which frequently enters through loose fitting windows, and warming it before it is distributed through the room. There are cases, however, where this is impossible as the space of the outside walls and near the front of the room, is occupied by important pieces of furniture, as is the case in chamber No. 3.

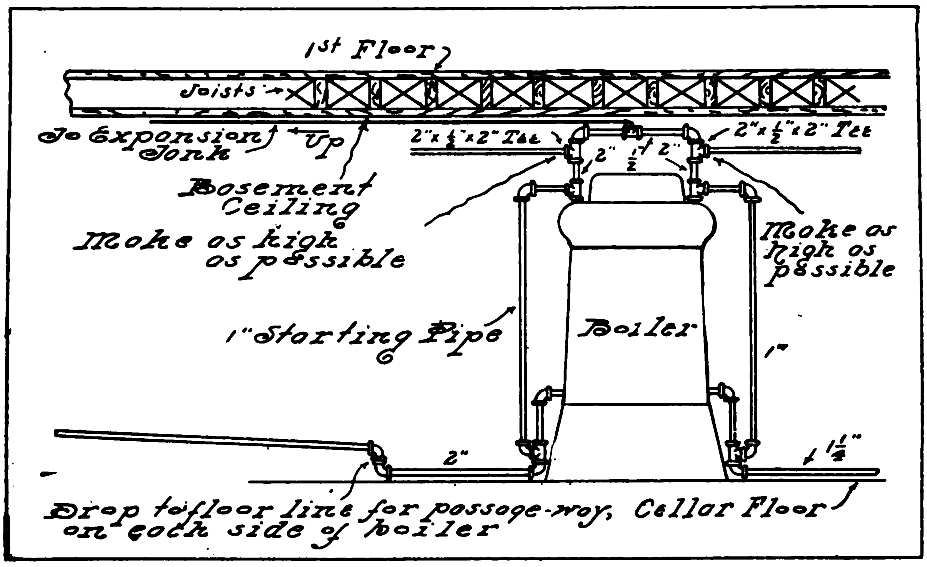


FIG. 247—SHOWING METHOD OF CONNECTING THE FLOW PIPE TO THE BOILER

Chamber No. 4 contains

18 square feet of glass.
270 square feet of exposed wall.
1800 cubic feet of air.

The radiator is placed on the outer wall, is 38 inches high and contains 60 square feet.

The bath room has

15 square feet of glass.
60 square feet of exposed wall.
855 cubic feet of air.

The radiator is 38 inches high and contains 30 square feet.

The rear hall contains:

18 square feet of glass.
172 square feet of exposed wall.
603 cubic feet of air.

The radiator is 38 inches high and contains 45 square feet.

Room No. 5 has

36 square feet of glass.
355 square feet of wall.
1570 cubic feet of air.

The radiator is 38 inches high and contains 80 square feet. The radiators in the bath room and the rear hall, are connected ¾ inch. All the other radiators are connected 1 inch.

The arrangement and sizes of pipe are shown on basement plan, Fig. 244.

There are 889 square feet of radiation on the first and second floors, and at some future time, there will be fifty to seventy-five square feet of radiation in the attic.

The boiler selected for this installation has a round fire pot, 28 inches in diameter, and is capable of running for ten hours without attention, maintaining during that period, a mean temperature in the radiation of 170 degrees.

Two 2-inch flow pipes are connected to the dome of the boiler, and rise to a point as high as possible above the boiler.

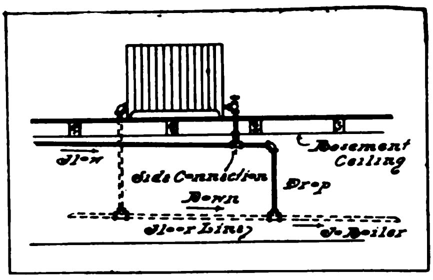


FIG. 248—DROP A, SHOWING RADIATOR CONNECTIONS

On the top of these risers are placed tees 2 x ½ x 2 inches. The ½-inch end of the tees are connected by ½-inch pipe, from which a 1-inch line of pipe is carried across the basement to the foot of a ¾-inch riser, which runs to the attic where it is connected to the expansion tank and tees are provided for the accommodation of the future radiator in the attic as is shown in Fig. 249.

The method of connecting the flow pipes to the boiler is shown in Fig. 247.

The 1-inch pipe which runs to the attic pitches up from the boiler. All the other pipes which leave the boiler pitch down, and at the extreme end, drop and are connected to the return which runs along the wall about two feet from the floor line, as shown in Fig. 250.

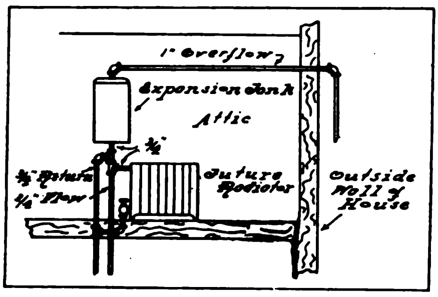


FIG. 249—SHOWING THE EXPANSION TANK, ETC.

Fig. 8 shows the return from the bath room risers, which is carried close to the ceiling of the basement and drops at a point marked "E," into the main return.

The 2-inch pipe which carries the radiation in the front of the building, has 419 square feet of radiation attached to it. After reaching the front wall, it is divided into two 1½-inch pipes. One of these 1½-inch lines carries 248 square feet; the other 170. Each 1½-inch line pitches down, and is continued about two feet beyond the last radiator connection, where they drop and are connected to the main return as shown in Fig. 250.

Nearly all the radiator and riser connections are taken from the side of this main. The reason for doing this is to produce a more even distribution of the heated water than can be obtained when the connection is taken from the top, because when the connections branch from side of the main it leaves an unbroken pathway for the flow of the heated strata of water along the top of the pipe, as is shown in Fig. 252.

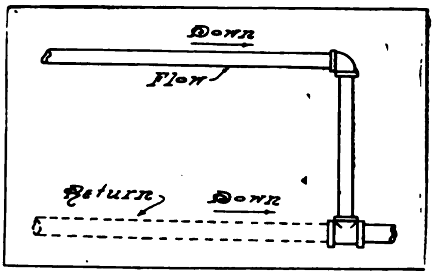


FIG. 250—DROP AT A, B, C, D AND F

When the branch for the radiator is connected to the top of the pipe, the flow of the water is broken at that point, and in many cases, retards the flow of the water to such an extent that the radiation is very unevenly heated, except when the water is leaving the boiler at very high temperatures.

The action of the heated strata of water is shown in Fig. 253. The return pipes in the plan, Fig. 244, are not quite equal to the flow pipes, but they will be found sufficiently large to do the work satisfactorily.

It will be necessary to drop the return

pipes below or flush with the cellar floor on each side of the boiler, which makes a lift of some 24 inches to the return, and as this water will be the coldest, and therefore, the heaviest, it will help the circulation to connect a 1-inch pipe from the flow pipe to the bottom of the lift, as is shown in Fig. 247.

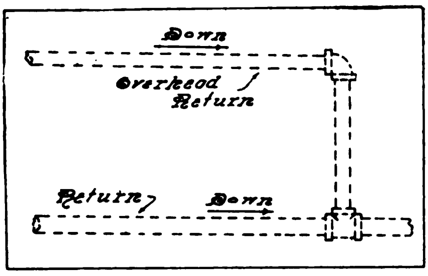


FIG. 251—SHOWING THE DROP AT E

A great deal has been written in the past and considerable attention is being given at present to pipe sizes for both steam and water heating apparatus. It is claimed that for hot water heating, the pipes must be large enough to prevent friction, and therefore it is quite customary to employ a pipe 3 inches in diameter to carry 500 or 600 square feet of radiation. It is also quite common to employ an 8-inch pipe to carry 5,000 or 6,000 square feet of radiation. All hot water heating apparatus which is designed with such large pipe is very sluggish in movement and requires an excessive amount of fuel for its operation.

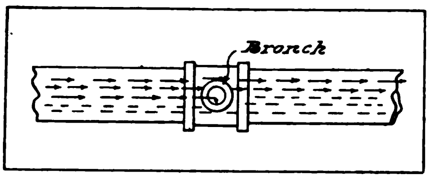


FIG. 252—SHOWING EFFECT OF SIDE OUTLET ON CONTINUOUS CIRCULATION

It not infrequently happens that when water heating apparatus is equipped with these excessive pipe sizes, only a portion of the radiation will heat when the water is at moderate temperatures, and whenever such a thing happens, the remedy prescribed is to put in larger pipe.

If the heating trade will pay a little more attention to velocity and less attention to frictional resistance, they will most assuredly get better results.

Those heating engineers who have studied this problem and succeeded in producing higher velocities in their pipe lines, are now using very small piping for both steam and water heating with marked success.

When excessively large flow pipes are employed for hot water heating, the water circulates within the pipe as is shown in Fig. 254, the hot water passing outwardly along the top of the pipe, and the cooler water flowing back into the boiler along the bottom of the pipe.

There are a large number of hot water heating plants operating in this manner to-day. Of course, if enough coal is burned in such plants, the house can be heated, provided there is an abundance of radiation and lots of boiler power, but in many plants it takes from three to five hours after starting the fire, to raise the temperature of the water high enough to heat the rooms.

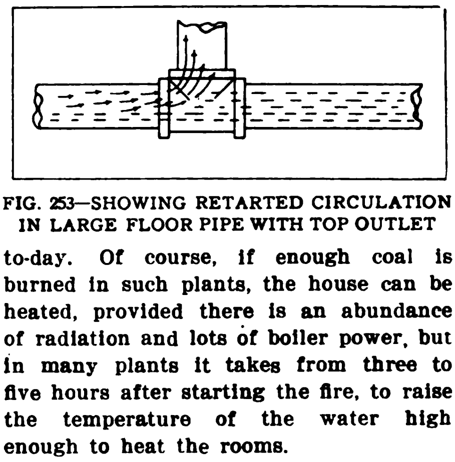


FIG. 253—SHOWING RETARTED CIRCULATION IN LARGE FLOOR PIPE WITH TOP OUTLET

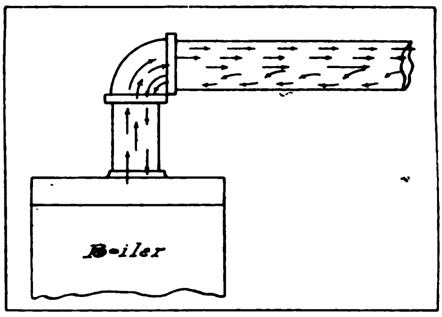


FIG. 254—SHOWING CIRCULATION WITHIN LARGE HOT WATER FLOW PIPE

When a hot water apparatus is piped as is described in this article, the circulation is very rapid and in thirty minutes after the fire is lighted, the radiators will begin to warm and can be heated throughout in less than half the time required by the jobs equipped with excessive pipes.

To raise the temperature of 400 gallons of water from 60 to 160 degrees F., requires the consumption of 40 pounds of good hard coal. To raise the temperature of 500 gallons of water from 60 to 160 degrees F., or through 100 degrees of temperature, requires the combustion of 50 pounds of hard coal, an increase of 25 per cent.

In a house heating job where there are approximately 2,000 square feet of radiation, it is easily possible to so reduce the pipe sizes that the apparatus will contain at least 100 gallons less water than is contained in a similar apparatus that is piped according to instructions that is piped according to prevailing methods.

When an excess of water is contained in an apparatus, a waste of fuel takes place every time the temperature of the water is raised, and this occurs more frequently than might be suspected. It is almost the universal custom to allow the temperature of the water to drop during the night and to replace the lost temperature in the morning by increasing the rate of combustion in the boiler.

CHAPTER LIV.

AN IMPROPERLY DESIGNED STEAM HEATING APPARATUS.

As an example of a bad job of steam heating, we submit Fig. 255. This is a job that was recently installed in the western part of New York State, and great care was taken by the contractors to have an apparatus that would be first class in every particular.

The boiler selected is of sufficient size, but when steam is raised the water fills a portion of the radiation, other radiators do not receive any heat, while an incessant hammer is heard in the piping.

Several changes have been made, but do not seem to help matters much. A check valve has been placed on the return, as it was supposed that the water left the boiler through the return and entered the radiation.

A view of the apparatus shows that the main steam pipe leaves the boiler 3 inches, and is reduced from time to time until it is 1¼ inches at the end of the circuit. At that point it drops to the main return, which is carried on the basement floor and connected to the boiler. The branches to the radiators are all 1¼ inch, and every branch is dripped into the return, as shown in Fig. 257.

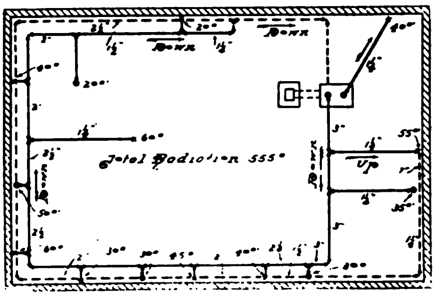


FIG. 255—A BAD JOB OF STEAM HEATING

Instead, however, of pitching the branch down to the drip, it is pitched up, so that the water of condensation in the lateral pipe flows back against the steam to the main, the drip taking care of the condensation in the riser and radiator to which it is attached.

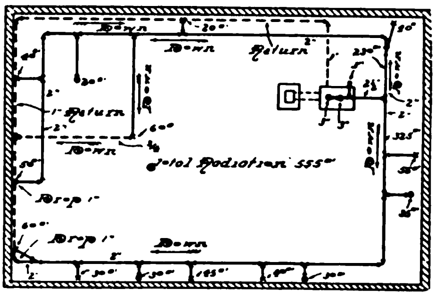


FIG. 256—A GOOD JOB OF STEAM HEATING

We do not know that there is any severe criticism of this method, but it would certainly be better practice if the branch were pitched down and then dripped. We contend, however, that there is no need of the drip in small work of this kind; that if the pipe were pitched up and of sufficient size, the comparatively small quantity of condensation would flow back to the main without causing any trouble. Where the arms are from 8 to 12 feet long, they should certainly be pitched down from the main and be dripped at the point where they rise to the radiator, this drip being carried back to a submerged return, if possible.

The trouble with this particular installation is that owing to the reduction in pipe sizes, a quantity of water is present at all times in the bottom of the pipe. If eccentric tees had been used, so that the bottom of the pipe would be in alignment, there would not have been any trouble, but as common reducing tees were used, the water rises in the larger pipes until it reaches the level of the next smaller size.

The trouble at the boiler is shown in Fig. 258, where only one 3-inch opening and one 1¼-inch is utilized. When the fire in the boiler is active the steam will leave the 3-inch opening at such a high velocity that it carries the water with it and into the piping.

The 1¼-inch line is used to heat but one radiator, and for some reason does not heat the radiator unless there is two or three pounds pressure at the boiler.

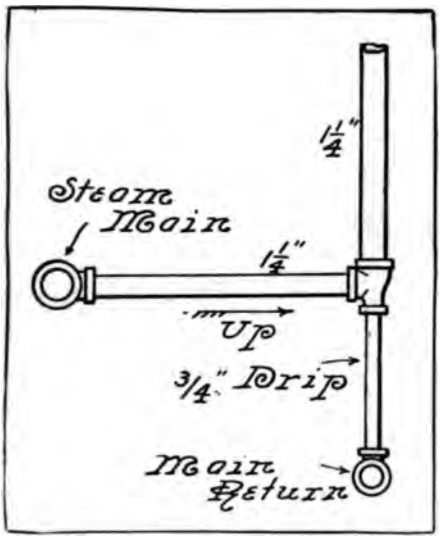


FIG. 257—A BAD JOB OF STEAM HEATING. BLEEDERS UNNECESSARY

This we attribute to the steam, at vapor or very low pressure, following the line of least resistance, which is the 3-inch main.

There are 555 square feet of radiation attached to the boiler to supply which a 3-inch main is used.

In this installation there was such an excellent opportunity to put in a good steam heating job, because of the shape of the building and because of the wet return being carried around the floor of the basement, that there was no excuse for using one circuit of pipe, because it is so easy to arrange the piping in two circuits, which will heat both sides of the house evenly and at the same time.

In Fig. 256 we show an arrangement of piping which we believe to be far superior to that shown in Fig. 255. In this revised system of piping the radiation is carried on two lines of pipe. Both these lines leave the boiler 2-inch and are carried that size until all the radiation for that line is picked up, when the 2-inch pipe is provided with a 2-inch by 1-inch elbow and drops to the wet return, which is carried along the basement floor back to the boiler.

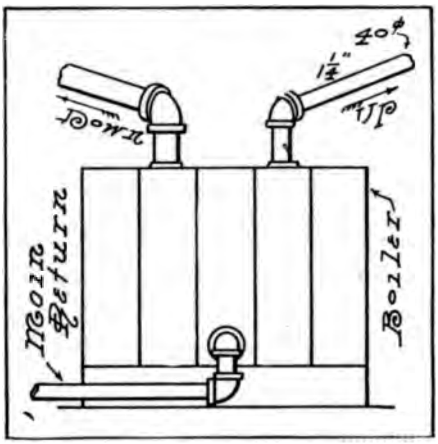


FIG. 258—A BAD JOB OF STEAM HEATING. BOILER CONNECTIONS

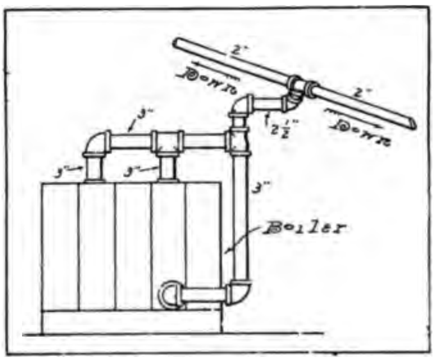


FIG 259—A GOOD JOB OF STEAM HEATING. BOILER CONNECTIONS

One 2-inch line carries 325 square feet; the other one 230 square feet. There are no drips or relief pipes from any of the branches, except the radiator in the hall, which is about 15 feet from the main. From that radiator a 1-inch pipe pitches down and is provided with a bull-headed tee. From the bottom of the tee a drip is carried back and connected to the wet return. From the other end of the tee the radiator is supplied through a 1¼-inch valve.

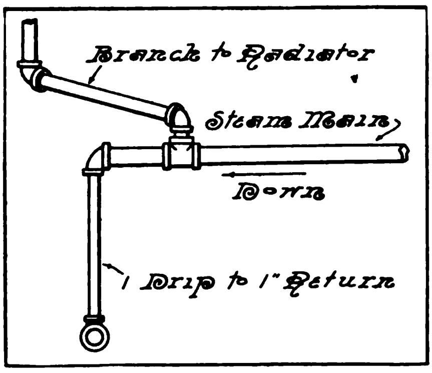


FIG. 260—A GOOD JOB OF STEAM HEATING. SHOWING DRIP AT END OF MAIN

The method of connecting the piping to the boiler is shown in Fig. 259, where two 3-inch pipes are connected to the steam dome. These two 3-inch risers connect to a 3-inch horizontal pipe, from the end of which a 3-inch drip or equalizer is carried back and enters the return of the boiler. From the top of the 3-inch horizontal main a 2½-inch pipe rises and connects with the two 2-inch mains.

By an arrangement such as this the steam leaves the dome of the boiler at a low velocity—about 8 feet per second in this case—and the office of the equalizer is to steady the water in the gauge glass. This arrangement will give perfectly dry steam in all the piping.

The method of connecting the 2-inch steam mains to the return is shown in Fig. 260, where a branch is shown leading to one of the radiators.

The idea among the inexperienced members of the heating trade seems to be that if the steam pipe is of large size it does not matter much how it is run or how the piping is arranged. If a little more care were taken to have an even distribution of the heat by running two or more semi-circuits, and if greater care were taken for a proper arrangement of boiler connections, the pipe sizes in present use could easily be cut in two and much better results obtained.

CHAPTER LV.

WATER HEATING APPARATUS IN A 12-ROOM SCHOOL HOUSE.

FIG. 261 represents the basement and piping plan for a hot water heating apparatus in a twelve-room schoolhouse, containing three floors and basement. Two cast iron sectional boilers are used, with 36-inch grate, each boiler having seven sections, 18 square feet of grate, and 166 square feet of heating surface. The catalogue capacity of each boiler is 4,450 feet.

From the top of one boiler two 5-inch nipples rise and are connected into 5x7 elbows. From the second boiler three 5-inch nipples rise and connect into 5x7 elbows.

When the job was installed lines D and F were run. The F line started with 7-inch pipe and was reduced at intervals as is shown on the plan. Line D started from the boiler 6-inch and immediately reduced to 5-inch, with other reductions as shown on the plan.

When the fire was started up it was found that the circulation stopped in line D at the point marked A and in line F at the point marked B. This stoppage

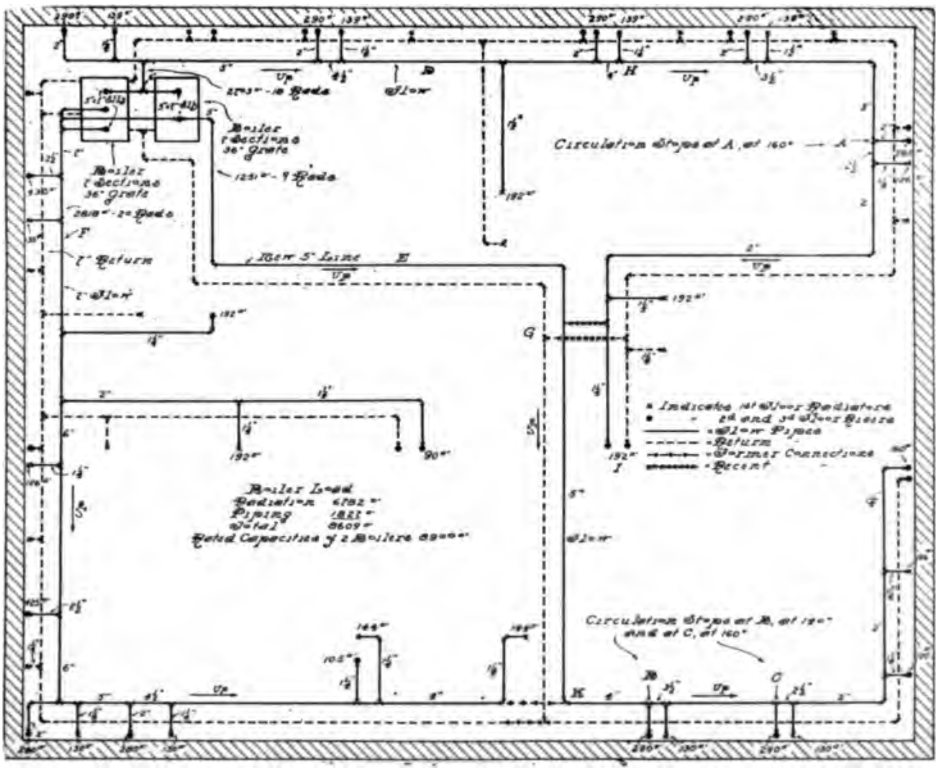


FIGURE 261—BASEMENT PLAN OF 12 ROOM SCHOOL HOUSE, 3 FLOORS AND BASEMENT

would be maintained while the water was leaving the boiler at a temperature up to 140 degrees. When the temperature of the water in the boiler rose to 160 degrees, the circulation would pass the stoppage at B and continue to the point marked C in line F, but it was necessary to raise the temperature of the water above 180 degrees to pass the obstruction at point A in line D.

The heating contractors who installed the apparatus supposed that their piping was not large enough, and consequently they run the new 5-inch line marked E, connecting it into line F at the point marked K, line F being cut out and plugged at this point. This did not seem to mend matters, even in line F.

They next made a connection from line E to line D at the point marked G, which helped warm up the tail end of line D.

Various reasons were assigned for the defective circulation, among others being that the boilers were too small; that the internal area of the boilers was insufficient to handle the water, and every reason on earth assigned except the right one, which is that the circulation stops at the points mentioned because of the abrupt reduction in pipe sizes, coupled with the fact that out of the top of the tees at those points a 2-inch riser is carried to the upper floors. As a result, the thin strata of water which is first heated, all goes up the 2-inch riser, and a false circulation is established in the flow pipe, the cooler water returning to the boiler along the bottom of the flow pipe.

All the pipes in all of these lines pitch up sharply from the boiler, as is customary in two-pipe basement work. In fact, it is contended by many heating men that it is the only way hot water will circulate, overlooking the fact that if water would not circulate down grade it would be impossible to get the return water from the radiators back to the boiler.

The piping for this apparatus is designed on very generous principles. The radiators on all the floors are used full size tapping, no reductions being made between the first and third floors. The risers are run the full size of the tappings and the heating contractors have endeavored to maintain the combined area of all the branches in the heating mains. Note, for example, the number and size of outlets taken from the top of the boiler. This system will, of course, make the flow of water from the boiler very sluggish; it cannot be otherwise.

As we have repeatedly stated in these articles, a steam boiler cannot have too many openings out of the steam dome, so that the initial velocity may be as low as possible, but in a water boiler we firmly believe that in the great majority of cases the area of the flow pipe leaving the boiler is entirely too large.

Our views in regard to this matter are shown in the basement and piping plan, Fig. 262. Here the same size of boilers is employed, but only one 5-inch riser is taken out of the top of each boiler. Line A and line B are both 5-inch flow and return, the size being the same throughout.

The high point of the piping is at the boiler, from which a ¾-inch pipe is taken and connected into the nearest riser, or it may be connected into the expansion pipe line. This vents all the piping in the basement. The pipes then pitch down to their extreme end, where they drop to the return, which is carried back on the basement wall about two feet from the basement floor, the return pipe grading downwards toward the boiler.

By this method all the water in the pipe, of different temperatures, flows in the same direction, whereas when a hot water main pitches up from the boiler, the water in the top of the pipe flows away from the boiler, while the water in the bottom of the pipe flows back to the boiler, so that we consider the down grade the better arrangement for uniform circulation.

In this arrangement of piping, Fig. 262, all the risers to the second and third floors are taken out of the side of the main. All the branches for the first floor are taken out of the top of the main. The returns from all of the radiators on all of the floors drop to the low return.

To heat the radiators at I a one-pipe circuit is started from the point marked H in line A, and after taking up two groups of radiators, each containing 192 square feet, is dropped into the 5-inch return. This pipe also pitches down, and here the flow pipe is taken out of the top of the 2-inch main, and the return pipe is connected into the side.

The radiation is more evenly divided by continuing line A to the corner, diagonally opposite to the boilers. This makes line A and line B of equal length.

It will be noted in Fig. 261 that some of the first floor radiators, containing 192 square feet, are fed with one 1¼-inch pipe. In Fig. 262 this pipe is increased to 1½ inch. At another point in Fig. 262 two radiators, containing 144 feet each, are each fed with one 1¼-inch pipe. In the remodeled pipe lines this pipe is in-

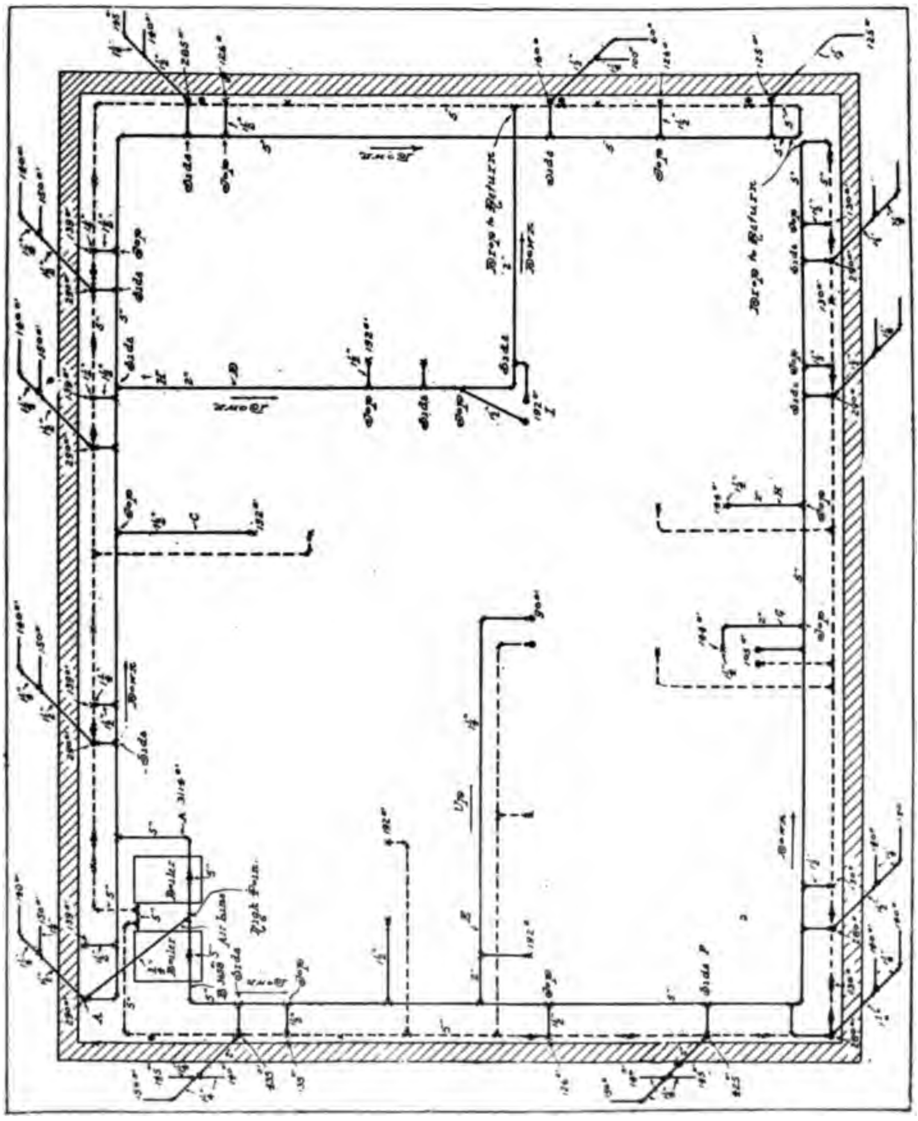


FIGURE 262—BASEMENT PLAN OF 12 ROOM SCHOOL HOUSE: PIPE LINES REMODELED

creased to 2-inch on the horizontal line and looks up 1¼-inch to the radiator.

The writer has been called upon three times in the last two months to inspect defective hot water heating apparatus, and in each case has found the pipes abnormally large and the defective circulation due to the large quantity of water which has to be handled, producing an extremely low velocity in the pipes and a circulation so feeble that the least little impediment stops the flow of water entirely.

In one case the radiation was spread over a considerable area and to obtain the necessary velocity the main pipe was carried from the boilers to the third floor, where the tank was connected, then dropped back to the basement, and was distributed to the radiators.

This method of distributing hot water is an excellent one, but in this particular case the heating contractors supposed that if they got the pipe large enough the job would take care of itself. As a result, they have used for their main riser to the expansion tank, a 9-inch main, which ought not to be more than 5-inch. A proportionate size of pipe was carried all through the building, with the result that the velocity is so low and the circulation so feeble that it is next to impossible to get an even distribution of the heat. Some changes have been made in the apparatus referred to, which have helped matters some, but it will never be a satisfactory working job, notwithstanding the heating contractors have used long sweep elbows, and Y fittings and have followed out the injunction to maintain in the mains the full area of all branches.

As a contrast to these excessive pipe sizes in hot water heating, we show a sketch in Fig. 263 of a small water heating apparatus recently installed in a store, and which will heat throughout as soon as the density of the water is disturbed by a little fire.

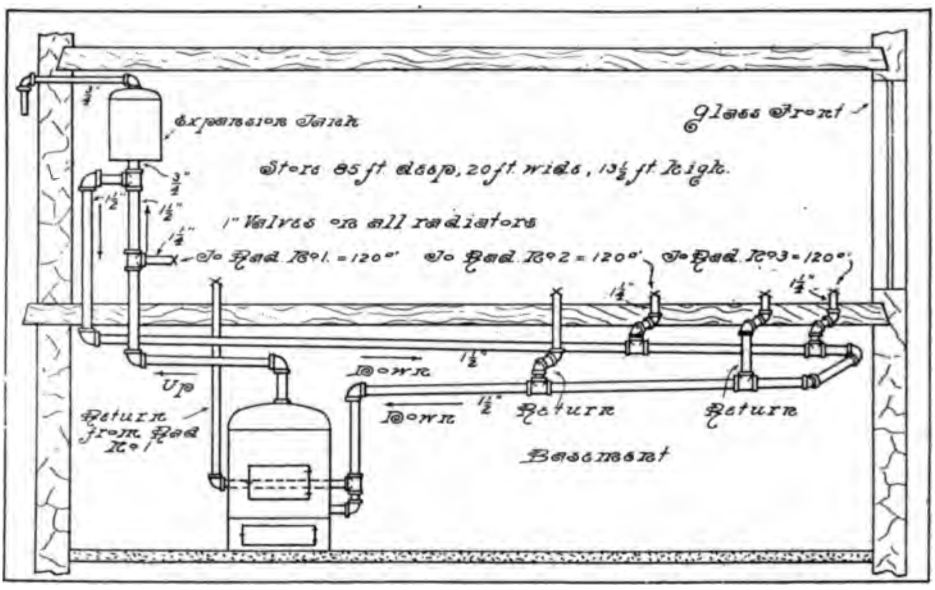


FIGURE 263—SKETCH OF A SMALL WATER HEATING APPARATUS RECENTLY INSTALLED

For example: If the water in the apparatus is at 40 degrees and enough fire is put in to change the temperature to 60 degrees, it will circulate throughout the entire job, and with a rapidity that is astonishing to the trade who have been accustomed to using large pipe sizes.

The customary practice is to start from boiler with a 3-inch main, reducing to 2¼-inch after the first radiator and grading flow and return lines up from the boiler.

CHAPTER LVI.

A FEW QUERIES ANSWERED.

I WOULD like to ask you whether it is correct to figure the second and other floor bed rooms the same as the first floor rooms. If figured the same, would not the heat from rooms on first floor rise up to the second floor and make it altogether too warm there? Have looked in all your articles in THE PLUMBERS' TRADE JOURNAL and have never seen it mentioned any other way, but to figure the same for every room in the house, usual allowances being made, of course, for difference in exposure of the different parts of the house and the construction of building.

Ocean City, N. J. J. R. G.

The writer does not consider it good practice to leave the heating of upper stories of a building to chance, and for that reason has always advocated and practiced treating each and every room according to its individual needs.

Some heat from the lower floor undoubtedly rises to the upper halls and some of the cooler air of the upper halls descends and mixes with the ascending warm air. As the warmer air rises from the lower floor, it may displace a small portion of the air in the upper halls by pushing it out through openings around window frames. But a very small portion of it will escape that way and it is certainly a matter of guess as to what quantity of heat can be depended upon to rise from the lower floor. It is good practice to place enough radiation in the lower hall to warm the hall on the second floor, provided that the second floor hall has no outside windows, but if there is a third floor hall, it is always best to place a separate radiator on the third floor, especially if there are outside windows in it. If the third floor hall is lighted by borrowed light, there would be no need of a radiator. It is a well-known fact among experienced heating men that the warm air from the first floor cannot be depended upon to heat rooms on a second floor. There are certain conditions under which a considerable quantity of heat would rise and there are other conditions under which a very small quantity of heat would rise to the upper floor. It is also well known to heating engineers that when there is an outside window on the stair landing between the first and second floors, cold air can be felt from that window when ascending the stairs. If a quantity of warm air was rushing up the stairway with sufficient volume to produce any material heating effect on the upper rooms the cold air from the window would not be noticed.

There is another reason why it is always best to figure the same proportion for upper floors as is figured for the lower floor and that is that the lower floor is frequently protected from the full force of the wind by board fences, hedges or similar obstructions, while the upper floors are more exposed to the full force of the wind and, therefore, frequently require a greater portion of heating surface than do the lower floor rooms. A very slight obstruction will deflect air currents from the lower windows and direct them against the upper part of the house as is shown in Fig. 264.

Editor of THE PLUMBERS' TRADE JOURNAL:

Have been much interested in your JOURNAL and gained considerable information from it. A Mr. Thompson is advocating very small flow and return pipes for hot water plants. Out here where hard coal costs $10 per ton we use large pipes and long sweep fittings, 45-inch ells, etc., to be more economical of fuel. We would like to compare records between some of our plants so rigged and some equal sized rigged with his small pipes. J. B.

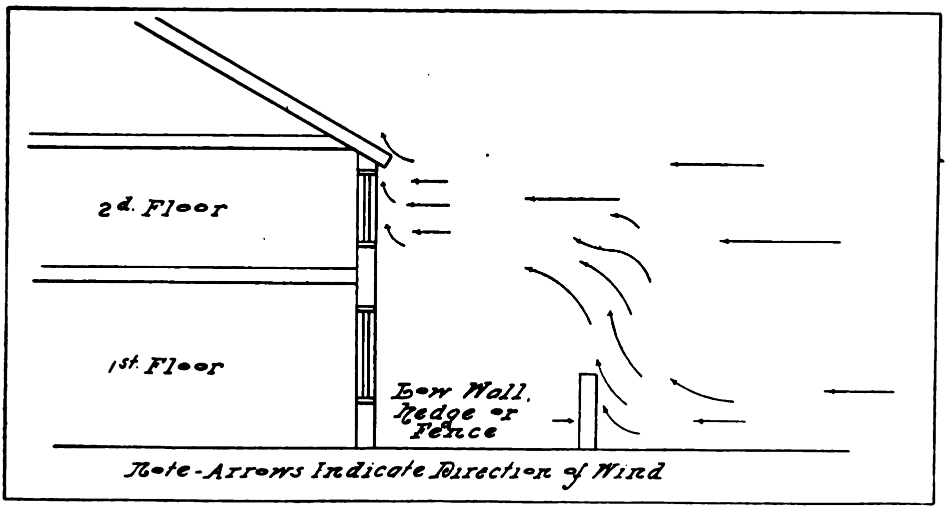


FIG. 264—A VERY SLIGHT OBSTRUCTION WILL DEFLECT AIR CURRENTS FROM LOW WINDOW

In regard to advocating small pipe sizes for water heating, the writer has endeavored to show methods by which the velocity of the water circulating through the pipes may be increased, thereby permitting the use of smaller pipe sizes than is customary.

Our correspondent must surely know that the sizes of pipe required for water heating apparatus depend upon the velocity attained by the water when passing through the system. The circulation of water due to a difference in the density of weight of two columns is very imperfectly understood.

There is not one hot water fitter in five hundred who has the slightest idea how fast the water is going through the pipe under a given set of conditions, nor do they know anything about the proper means to stimulate or accelerate circulation.

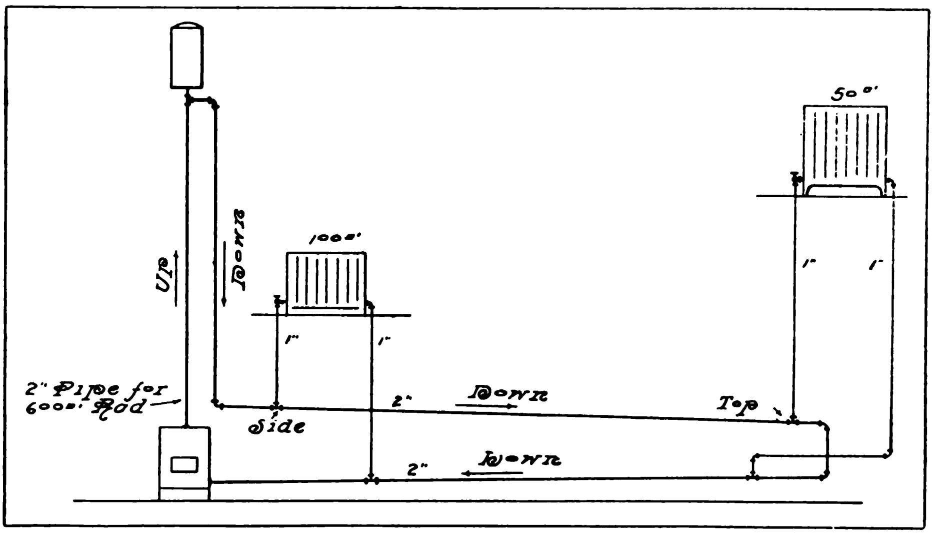


FIG. 265—OUR CORRESPONDENT CANNOT DO BETTER THAN TO INSTALL IT ACCORDING TO THIS SKETCH

When we see a water heating apparatus equipped with long sweep fittings and abnormal pipe sizes we know that the designer of such plant is simply working by tradition and has no scientific basis to guide him.

That large pipe sizes in hot water heating apparatus make for economy is a false assumption and our correspondent cannot do better than to take a job of 500 or 600 square feet and install it according to the principles shown in sketch, Fig. 265, using only the ordinary fittings and then compare that with a job of similar size where they have used much larger pipe and especial fittings. A little experiment like this will do more to convince them of the folly of excessive pipe sizes than all the arguments we can adduce.

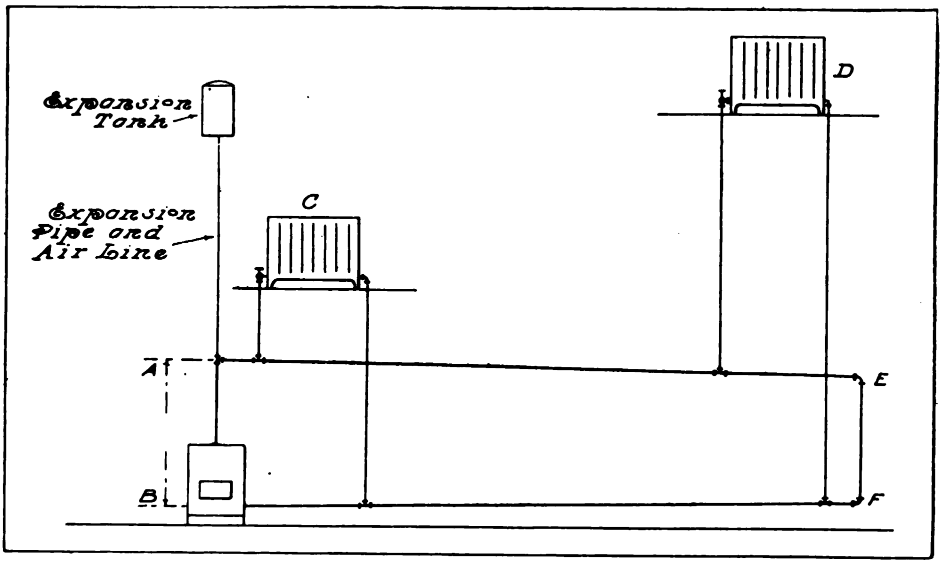


FIG. 266—A SYSTEM OF FALLING CIRCULATION WITH DROP BETWEEN THE FLOW AND RETURN AT A POINT FURTHEST FROM THE BOILER

Editor of THE PLUMBERS' TRADE JOURNAL:

In your issue of February 1, 1906, under the heading "Steam and Hot Water Heating," you publish basement piping plans of a twelve-room school, showing two systems. The one, Fig. 261, is very clearly wrong, and the exceptions to it are certainly well taken as it is defective in way in which your correspondent claims.

I would like to ask your correspondent through your JOURNAL, first, at how slight a change in the temperature of the water can he get a perfect circulation in all parts of the system when fitted up as shown by Fig. 262, and second, what special gain does he claim for having the return carried back so low down?

The form of the average building would not permit of that being done except perhaps such a building as he shows, and third, what advantage would Fig. 262 have over a similar system with pipes judiciously reduced by means of eccentric fitting, thus maintaining a perfect alignment of the top edge of both flow and return pipe? In future, I may take the liberty of going into the question of pipe sizes for jobs of different sizes, giving some Canadian experiences from a locality where hot water has been the leading system adopted for the past fifty years. J. D. J.

It is not possible to say at what difference in temperature an apparatus designed as shown in Fig. 262 would circulate, because that would largely depend upon the rate of cooling in the basement where the pipes are uncovered.

The reason for showing the drop from the flow pipe to the return pipe at the end of the line furthest from the boiler is because that position gives a quicker and steadier circulation than when the return pipe is carried back on the same level as the flow pipe and is dropped at the boiler.

In Fig. 266 we show a system of falling circulation with the drop between the flow and return at a point furthest from the boiler. This point, we have marked E F. The motive power, or that power which circulates the water through the mains, is the difference between the temperature of the water contained in E F and that contained in the column A B.

In Fig. 267 we show the usual rising circulation with the flow and return run side by side and the drop in height between the flow and return is made at the boiler as shown by the letters E F. In this instance the radiator B, which is nearest the boiler, will discharge its return water into the return line close to the drop, and will, in a short time, heat the water in that column to a temperature almost as high as that contained in the Column A B with the result that radiator C and other remote radiators will have a very feeble circulation or none at all. Any means which may be employed to increase the flow of water through the piping and radiation of a water heating apparatus, permits the use of smaller pipe. Smaller pipe contains less water and as a consequence the tax on the boiler and fuel is less than where excessive pipe sizes and slow circulation obtain.

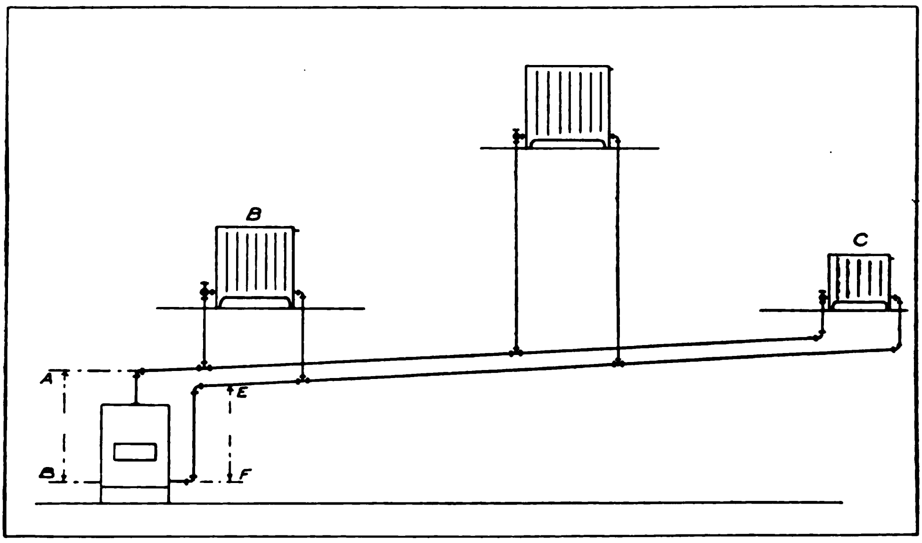


FIG. 267—THE USUAL RISING CIRCULATION WITH FLOW AND RETURN RUN SIDE BY SIDE

CHAPTER LVII.

PRACTICAL INFORMATION.

INASMUCH as many of the standard tables, such as Area and Circumference of Circles, Properties of Saturated Steam, Dimensions of Wrought Iron Pipe, etc., are published in convenient form in so many trade catalogues, it was deemed best to publish only a few odd tables at the end of this book.

A portion of the information contained in this chapter is derived from Kent's Mechanical Engineers' Pocket Book.

APPROXIMATE WEIGHTS OF FUEL.

1 cu. ft. Lackawanna Anthracite Coal..50 lbs.
1 cu. ft. best Lehigh Coal............55 lbs.
1 cu. ft. average Soft Coal...........40 lbs.
1 cu. ft. average Coke................28 lbs.

SPACE OCCUPIED BY FUEL.

1 ton (2,000 lbs.) Lackawanna Coal.40 cu. ft.
1 ton (2,000 lbs.) Lehigh Coal.......36½ cu. ft.
1 ton (2,000 lbs.) Average Soft Coal.50 cu. ft.
1 ton (2,000 lbs.) Coke ....70½ cu. ft.

WATER—STEAM—AIR.

At Atmospheric Pressure.

1 cu. ft. of water at 39.2 deg. F. weighs.62.5 lbs.
1 cu. ft. of air at 32 deg. F. weighs...0807 lbs.
1 cu. ft. of steam at 212 deg. F. weighs..03794 lb.

Water, then, is about 775 times heavier than air, and 1,650 times heavier than steam.

Air is 2.12 times heavier than steam, and 775 times lighter than water; hence, in water heating apparatus, the air must be vented at the top and on high spots.

In steam heating apparatus, the air vents must be at or near the bottom.

EXPANSION OF PIPE.

Length that 100 feet of wrought iron pipe will expand in inches or fractions of an inch, when heated from its temperature when fitted to the following temperatures in Faht. degrees.

Temperature of pipe when fitted, F. deg.	150 inches	180 inches	200 inches	220 inches	240 inches
0	1.20	1.44	1.60	1.76	1.92
20	1.04	1.28	1.44	1.60	1.76
40	0.88	1.12	1.28	1.44	1.60
60	0.72	0.96	1.12	1.28	1.44
80	0.56	0.80	0.96	1.12	1.28

The size of pipe is not considered; 100 feet of one inch pipe will expand or grow under heat to the same length as will 100 feet of 4-inch, or 10-inch pipe.

By the use of the above table, the expansion of pipe of any length may be determined by proportion.

Example: What is the expansion of 12 feet of pipe fitted at 40 degrees, and heated to 220 degrees?

Answer: 100 feet of pipe under those conditions will expand 1.44 inches, or nearly 1½ inches. If 100 feet expands 1.44 inches, 1 foot will expand one-hundredth part of 1.44, which is .0144; then, if 1 foot expands .0144 inches, 12 feet will expand 12 times .0144, which is .1728 inches, or about 11-64ths of an inch; 17.18 is the decimal equivalent of 11-64ths of an inch. See any table of decimal equivalents.

MEASURES OF CAPACITY.

1 U. S. gallon of water weighs at 62 deg. F. 8.3356 lbs.
1 U. S. gallon of water contains....231 cu. in.
1 Imperial gallon of water at 62 deg. F. weighs ....10 lbs.
1 Imperial gallon of water contains 277.274 cu. in.
7.48 U. S. gallons...................1 cu. ft.
6.25 Imperial gallons................1 cu. ft.

NOTE—The Imperial Gallon is the standard in Great Britain and Canada.

MEASURES OF LENGTH.

12 inches.............................1 foot
3 feet................................1 yard
5½ yds. or 16½ ft......1 rod, pole, or perch
40 rds. or 220 yds.................1 furlong
8 furlongs, or 1,760 yds., or 5,280 ft....1 mile
3 miles...............................1 league
6,080 feet............1 knot or nautical mile
100 knots.......................115.15 miles

SQUARE MEASURE.

144 sq in..........................1 sq. ft.
183.35 circular inches...............1 sq. ft.
1,728 sq. in.........................1 cu. ft.
27 cu. ft............................1 cu. yd.
9 sq. ft.............................1 sq. yd.
30¼ sq. yds. or 272¼ sq. ft........1 sq. rd.
40 sq. rods ....1 rood
4 roods or 160 sq. rods, or 4,840 sq. yds.,
or 43,560 sq. ft..................1 acre
640 acres...........................1 sq. mile

A plot of ground measuring:
208.71 x 208.71 feet..........equals 1 acre
91 x 120 feet................equals ¼ acre
100 x 109 feet...............equals ¼ acre
40 x 136 feet................equals ⅛ acre
25 x 109 feet................equals 1/16 acre

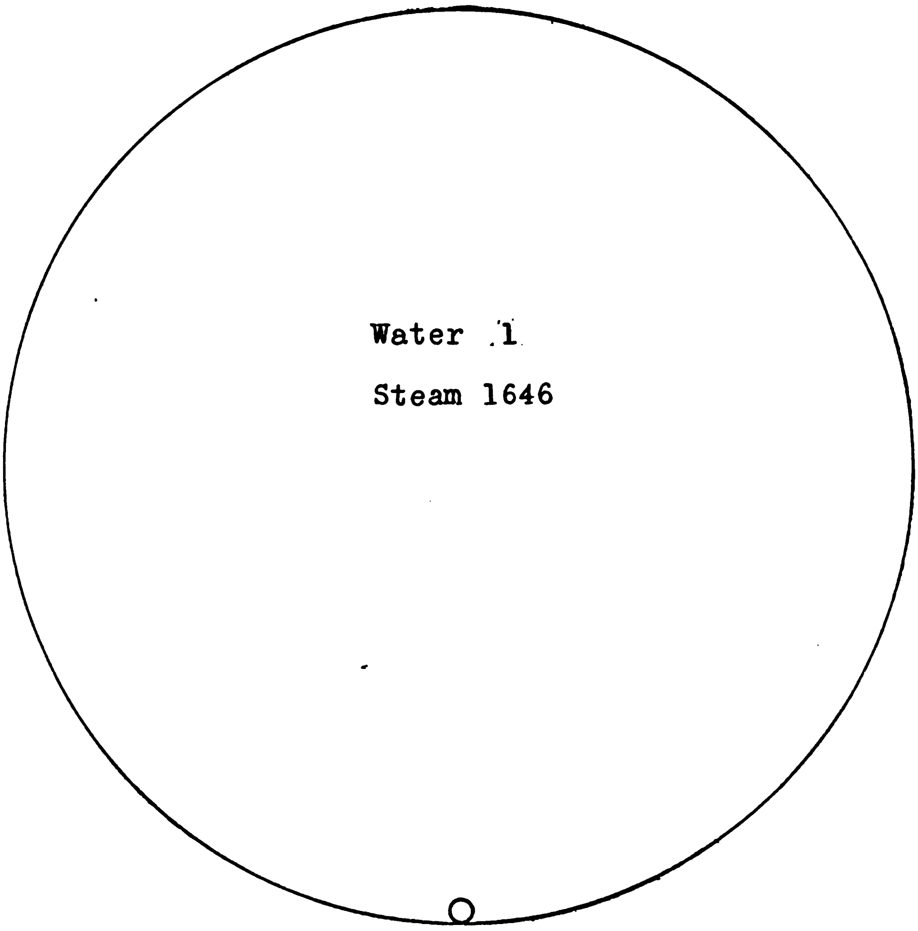
1 cord of wood equals a pile 4 x 4 x 8 ft. equal to 128 cu. ft.

BRICKWORK.

8¼ in. wall or 1 brick thick, 14 bricks per superficial foot.

12¾ in. wall or 1½ bricks thick, 21 bricks per superficial foot.

17 in. wall or 2 bricks thick, 28 bricks per superficial foot.



RELATIVE VOLUME OF WATER AND STEAM AT ATMOSPHERIC PRESSURE. THE SMALL CIRCLE REPRESENTS WATER; THE LARGE CIRCLE REPRESENTS THE SAME QUANTITY OF WATER IN FORM OF STEAM.

200 x 217.8 feet..............equals 1 acre
150 x 290 feet................equals 1 acre
120 x 362 feet................equals 1 acre
100 x 435.6 feet..............equals 1 acre
145 x 150 feet................equals ½ acre
72.5 x 150 feet...............equals ¼ acre

21½ in. wall or 2½ bricks thick, 35 bricks per superficial foot.

Average weignt of red brick, 8¼ x 4 x 2 inches, 4½ lbs.

26.2 bricks to a cu, ft.

Water is a poor conductor of heat.

Therefore, water at rest is a poor absorber of heat, but when in motion, it has a large capacity for carrying heat; hence, a water heating apparatus containing a small quantity of water circulating rapidly, is more economical of fuel than is an apparatus which contains a large quantity of water and has a sluggish circulation, because in the high velocity apparatus, the heat from the fuel is more rapidly taken up and a higher percentage of fuel power is thus available.

STEAM CONDENSATION IN WATER AND IN AIR.

The rate of condensation in a steam-filled pipe, surrounded by water is approximately 100 times greater than when it is surrounded by air. That is, while 100 square feet of pipe is condensing in air, 25 pounds of steam—the same quantity of pipe will condense in water—2,500 lbs. This is only approximate.

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